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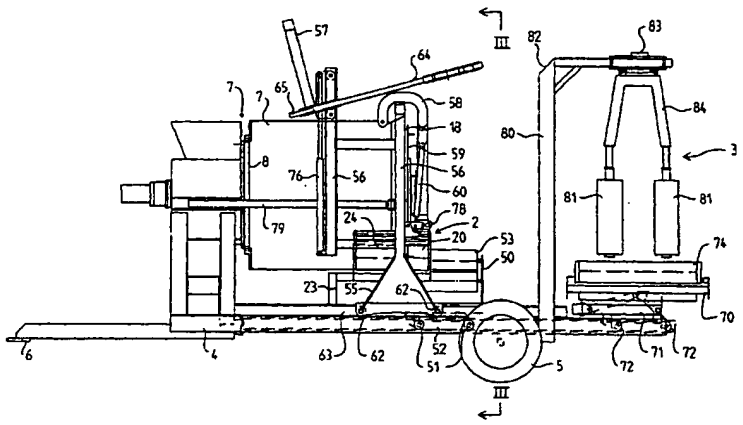
(54) Title: A COMPACTING AND WRAPPING MACHINE



(57) Abstract: A wrapping machine for wrapping materials, in particular compacted bales (20) of material such as fodder, loose materials and the like with a strip of wrapping material such as plastics film. It comprises a first wrapping station (2) having wrapping means (94) for applying a strip of wrapping around the bale to partially wrap the bale (20) in wrapping material, a second wrapping station (3) having wrapping means (41, 63) for applying a strip of wrapping material around the bale to completely wrap the bale (20) in wrapping material, and transfer means (50) for transferring the partially wrapped bale (20) from the first wrapping station (2) to the second wrapping station (3). The partial wrapping of the bale prevents its disintegration during transfer. The transfer means (50) is swingable, to transfer the bale (20), through approximately 90° from the first wrapping station (2) to the second wrapping station (3). The first wrapping station (2) includes wrapping means comprising a dispenser (94) for dispensing a strip of plastics film, and means for rotating the dispenser, about a substantially vertical axis, around the bale to partially wrap the bale. The second wrapping station (3) includes means, for rotating the bale about a substantially horizontal axis, and at least one dispenser (4), for dispensing a strip of wrapping material and means for rotating the dispenser (41) around the bale as the bale (20) is turned about the horizontal axis. The invention also includes a compaction station (1) having a compactor (10) for compacting loose material into a bale (20), before wrapping. The compactor (10) comprises a compaction chamber (7), open at both ends, means (87) for directing loose material into the chamber (7), a rotating compaction head (15) including at least one roller (13) rotatable over the loose material within the compaction chamber (7), and capable of moving within the compaction chamber (7) as loose material accumulates within the chamber (7) to compact the material in the chamber (7). Preferably, the compaction chamber (7) is moveable upwardly in a vertical direction as the bale (20) is being formed to expose a part of the partially-formed bale (20), and wrapping means (94) are included to wrap an exposed part of the bale (20) with wrapping material as the compaction chamber (7) is raised.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A COMPACTING AND WRAPPING MACHINE

Field of the Invention

The invention concerns a combined compacting and wrapping machine for compacting material into bales and wrapping the bales with plastics film. The invention is particularly concerned with a machine for forming bales of agricultural silage, grain, hay, straw, maize, beet pulp, beet tops, and the like (hereinafter referred to as "fodder") and wrapping the formed bales with a plastics film, which preferably is air tight and water tight. The machine of the invention may also be used for compacting and wrapping general farm and agricultural waste products, such as waste plastics and the like, and for compacting and wrapping other loose materials and objects such as comminuted peat moss, saw dust, wood shavings, wood chippings, brewery waste, bricks, blocks, cartons and the like.

Background of the Invention

It has become conventional practice in agriculture to form harvested fodder into cylindrical-shaped bales, and square or rectangular bales, which are then wrapped in a plastics film. This is particularly suitable method of manufacturing silage because the silage is kept air-tight within the wrapped bale which, typically, is wrapped with up to six plies of plastics. The cylindrically shaped bales are commonly called "big round bales".

In the conventional method of producing wrapped bale fodder, such as silage, at least three machines are used. Firstly the grass or other fodder for use as silage is cut, in a field, by a cutting machine. The cut grass is left on the surface to wilt and is turned periodically by a tedding machine. A conventional baling machine then traverses the field, picks up the cut grass, compacts it into a round bale, ties it with twine, and deposits it on the ground. A bale wrapping machine then traverses the field, picks up the compacted and tied bales, and wraps the bales with several layers of a plastics film,

and drops the wrapped bales on the ground. The wrapped bales are subsequently gathered and brought to a storage area. Alternatively, the compacted and tied bales may be transported to the storage area before wrapping and are wrapped in the storage area by a bale wrapping machine.

WO 99/04613 of the same applicant discloses a wrapping machine for wrapping materials, in particular compacted bales of material, with a strip of wrapping material comprising a first wrapping station having wrapping means for applying a strip of wrapping around the bale to partially wrap the bale in wrapping material, a second wrapping station having wrapping means for applying a strip of wrapping material around the bale to completely wrap the bale in wrapping material, and transfer means for transferring the partially wrapped bale from the first wrapping station to the second wrapping station.

WO 99/04613 also discloses a combined compacting and wrapping machine for compacting material, such as fodder, loose materials, and the like, into a bale and wrapping the bale with a wrapping material, such as plastics film, comprising a compacting station including a compactor for compacting loose material into a bale and means for moving the compacted bale from the compacting station to at least one wrapping station having means for wrapping a strip of wrapping material, suitably a plastics film, around the bale. The compacting station and wrapping station are combined in a single machine by mounting them on the same chassis or platform. The compactor comprises a vertically disposed compaction chamber, open at the top, means for directing loose material into the chamber, a rotating compaction head including at least one roller rotatable over the loose material within the compaction chamber, and capable of moving within the compaction chamber to compact loose material accumulating within the chamber. The rotating compaction head is carried on two downwardly extending support arms which extend into the chamber, and the support arms are slideable in a vertical direction along a vertical support column mounted on the machine. The compaction head, which rotates about a substantially vertical axis, carries two rollers which are rotatable about substantially horizontal axes. The compaction chamber is moveable upwardly in a vertical direction as the bale is being formed to expose a part of the partially-formed bale, and wrapping means are included to wrap an exposed part of the bale with wrapping material as the compaction chamber is raised.

It has been found that there are a number of problems associated with WO 99/04613. Firstly, because the compaction chamber is vertically oriented, and in one embodiment, moves vertically upwardly when the bale is being compacted, the machine

is very high. Also, the feed inlet of the machine is moving vertically during the feeding-in of the material to the machine which makes it difficult to direct material from the chute of a forage harvester or the like. Also, the machine operates on basis of an intermittent rather than a continuous compacting operation.

Object of the Invention

It is an object of the invention to overcome certain of the disadvantages of the known apparatus and to provide an improved compacting and wrapping machine for compacting bales of fodder and other loose material into compact bales and wrapping the bales in plastics film. It is also an object to provide a machine which is lower and more compact that the prior art machine, and which operates in a continuous manner.

Summary of the Invention

The invention provides a compacting and wrapping machine for compacting material into bales and wrapping the bales in wrapping film, comprising a compaction chamber having an inlet at one end and an outlet at the opposite end, compaction means within the compaction chamber for compacting material fed into the inlet end, and extruding compacted material from the outlet end, wrapping means located at the outlet end of the chamber for wrapping extruded material in wrapping film, wherein the axis extending from the inlet end to the outlet end of the compaction chamber is substantially horizontal, and means are provided for rotating the compaction chamber about said substantially horizontal axis during compaction of material within the chamber.

In accordance with another aspect the invention concerns a compacting and wrapping machine for compacting material into bales and wrapping the bales in wrapping film, comprising a compaction chamber having an inlet at one end and an outlet at the opposite end, compaction means within the compaction chamber for compacting material fed into the inlet end, and extruding compacted material from the outlet end, wrapping means located at the outlet end of the chamber for wrapping extruded material in wrapping film, wherein the chamber is horizontally oriented and has a pressure plate located at the outlet end of the chamber and includes pressure means for pressing the pressure plate against the material as it is extruded from the chamber.

Preferably a cutting means is provided at the outlet end of the chamber to cut the extruded material into discrete bales.

The machine provides a second wrapping station having a wrapping platform which is moveable from a position adjacent the outlet end of the compaction chamber, to a second position at said wrapping station, the wrapping platform being adapted to receive a compacted and partially wrapped bale at the outlet end of the compaction chamber and conveying the bale to the second wrapping station for the completion of the wrapping.

The invention also includes a method of compacting and wrapping materials wherein the method includes the following steps:

a) feeding the material to be compacted into one end of a compaction chamber of a compactor;

b) rotating a compaction head against the loose material within the compaction chamber, to compress the material into a bale and extruding the bale from an outlet end of the chamber;

c) wrapping an exposed part of the partially-formed bale at a first wrapping station located at the outlet end of the compaction station, with a strip of wrapping material sufficient to maintain the integrity of the bale, without the need for cord, twine, or the like, cutting the extruded and partially wrapped bale to a desired length; and

d) transferring the partially-wrapped bale to a second wrapping station where wrapping of the bale with a film of wrapping material is completed.

Brief Description of the Drawings

Some embodiments of the invention are hereinafter described with reference to the accompanying drawings, wherein:

Figures 1 is a front perspective view of a first embodiment of a combined compacting and wrapping machine of the invention;

Figure 2 is a side elevation of the machine of Figure 1;

Figure 3 is an end elevation on the line III - III of Figure 2;

Figure 4 is a plan view;

Figure 5 shows a detail of the machine;

figure 6 shows an alternative detail;

Figures 7 to 12 are side elevations of the machine of Figure 1, at different stages in the wrapping operation;

Figure 13 is a side view of another embodiment of the machine of Figure 1;

Figure 14 is a front perspective view of a further embodiment of the machine of Figure 1 showing an alternative cutting device;

Figure 15 is an end view of the cutting device of Figure 14; and
Figure 16 is a top plan of the device of Figure 15, and
Figures 17 to 19 are end views of further embodiments of cutting devices.

Detailed Description

A first embodiment of a combined compacting and wrapping machine of the invention, and its method of use, is illustrated in Figures 1 to 12. The machine, which is towed by a tractor comprises a compacting station 1, a first wrapping station 2, and a second wrapping and tipping station 3. The compacting station 1 includes a horizontally disposed compactor 10.

The combined compacting and wrapping machine of the invention comprises a compacting station 1, a first wrapping station 2, and a second wrapping station 3. The stations 1, 2 and 3 and the component parts thereof as described below are all mounted on a chassis 4 having a pair of wheels 5. The chassis has a hitch 6, at a front end thereof, for attachment to a tractor.

Referring particularly to Figures 1 and 4, the compacting station 1 comprises a substantially horizontally disposed compacting chamber 7. The chamber 7 is substantially cylindrical in shape. It has a feed inlet 8 at a forward end of the chamber 7 and an open outlet 18 at the opposite end of the chamber 7. A hopper 40 is positioned at the inlet 8 to feed material to be compacted to an auger 41 located at the bottom of the hopper 40.

The compaction chamber 7 is mounted above the chassis 4 and extends longitudinally and horizontally of the machine. It is supported by a support structure 9, which extends upwardly at the front of the machine. In the embodiment shown, the compaction chamber 7 is rotatable about its horizontal axis.

A detail of the forward end of the compaction chamber 7 is shown in Figure 5. An annular toothed slew ring 10 is welded to an annular flange 42 which defines the open end of the compaction chamber 7. The slew ring 10 rotates relative to a fixed ring 43 by means of a roller bearing 44. The ring 43 is welded to an annular fixed plate 45. The slew ring 10 is driven by a hydraulic motor 46 mounted on the plate 45. The motor 46 has a drive shaft on which is mounted a pinion 47 which engages with the toothed slew ring 10, to rotate the chamber 7 about its horizontal axis.

As shown in figure 5,a compactor 11 is positioned in the chamber 7 adjacent the forward open end 8 of the compacting chamber 7. The compactor 10 has a rotating compaction head 15 consisting of rollers 16, which may have cleats on the surface thereof. The particular roller arrangement used will depend upon the material to be compacted because it has been found that certain roller arrangements or combinations operate more satisfactorily that others for certain materials.

The compaction head 15 rotates in a direction counter to that of the compaction chamber 7.

The compacting wheels or rollers 16 may be of different shapes, e.g. they may be of cylindrical or of conical shape. The number of rollers 16 may vary, e.g. the compacting head 15 may support two, three or four rollers 16. The drive arrangement for the roller 16 may also vary. For example, the compacting head 15 may be powered for rotation while the rollers 16 are freely rotatable but not powered. Alternatively, the rollers 16 are powered for rotation while the head 15 is freely rotatable but not powered. In yet another arrangement both the head 15 and the rollers 16 are powered for rotation.

In the embodiment shown in Figure 5, the rotary head 15 is driven by a hydraulic motor 27 mounted on the top of the support structure 9. The motor 27 is connected to a planetary reduction gear box 32, which has a drive-output spigot 33. A drive shaft 34 is detachably mounted to the spigot 33, for example by a retaining screw. The rollers 16 are carried on the lower end of the shaft 34 by inclined stub axles 35. A roller 16 is journalled for free rotation on the end of each axle 35. Thus, rotation of the shaft 34 causes the compaction head 15 to rotate. In the drawing two rollers 16 are shown. However, the head 15 may easily be detached from the spigot 33 and replaced with a head 15 containing three or more rollers. The rollers 16 may be fitted with cleats where appropriate.

In the embodiment shown in Figure 5, the feed auger 41 is driven by the motor 27 through the reduction gear box 32 by mounting the feed auger 41 on shaft 34. Thus, the feed auger rotates at the same speed, and in the same direction as the compaction head 15.

In an alternative arrangement, as shown in Figure 6 the feed auger 41 is driven independently of the compaction head 15, and in a direction counter to the compaction head 15. This is achieved by mounting the auger 41 on a hollow shaft 36 which rotates around, and coaxially with, the outer part of the shaft 34. the hollow shaft 36 is driven

by a separate hydraulic motor 37. A chain drive 38 transmits drive from an output shaft of the motor 37 to the shaft 36 in well known manner. In this way both the speed of rotation and direction of rotation of the auger 41 may be controlled independently of the compaction head 15.

The first wrapping station 2 is located at the inner end of the compaction chamber 7 adjacent an outlet end 18 of the chamber 7. The wrapping station 2 comprises a plastics film dispenser 20 which is adapted to wrap film about the exposed compacted bale 21 as it emerges from the chamber 7, as described in more detail below.

As shown in Figures 2 and 3, the first wrapping station comprising the film dispenser 20 is located adjacent to, and below, the outlet end 18 of the compaction chamber 7. The film dispenser 20 comprises a freely rotatable shaft 22 carried on a support arm 23. The shaft 22 carries a roll of plastics film 24. This film 24 passes through a tensioning device 25 of well-known construction and operation. The film dispenser is located in overlapping arrangement with the end 18 of the compaction chamber 7 such that when the film 24 is dispensed from the film dispenser, as shown in Figure 3, to wrap a bale 21 emerging from the opening 18, it also overlaps the end of the chamber 7 so that it is unwrapped from the roll of film by the rotation of the compaction chamber 7, which turns in the direction of the arrow shown in Figure 3.

A trolley 50 is located adjacent the outlet end 18 of the chamber 7. As shown in Figure 3, the trolley 50 has wheels 51 which are moveable along rails 52 which extend longitudinally of the chassis 4. A plurality of bale support rollers 53 are rotatably mounted on the trolley 50. The trolley 50 is moveable, along rails 52, from the position shown in Fig. 2 to the position shown in Fig. 8, as described more fully below. The purpose of the rollers 53 is to support the end of the compacted bale 21 as it emerges from the compaction chamber 7.

A gantry 56 is located at the rearward end of the compaction chamber 7, adjacent the outlet end 18 of the chamber. The gantry 56 comprises two upright members which extend vertically, one at each side of the chassis 4. A circular steel pressure plate 59 (see Fig. 3) is mounted for rotation on a frame 54. The frame 54 is hinged at the top to brackets 58 which are welded to, and extends forwardly of the gantry 56. The pressure plate 59 is shown, in Figure 10, in an open position, in which it extends substantially horizontally above the compaction chamber 7 to clear the outlet end 18 of the chamber 7. The pressure plate 59 is swingable from this position, about the hinges on brackets 58, down to the position in Figure 1 in which it fits against the rearward end of chamber 7 to close the outlet 18. In this position the lower part of the frame 54, carrying the

pressure plate 59, is locked in position by means of latches 78, located one to each side of the gantry 56, The latches 78 are released by operation of rams 60.

The path of travel of the pressure plate 59 is shortened because of the forward position of the hinge on brackets 58. The purpose of the pressure plate 59 is to react against the pressure of the compacting material within the chamber 7 as a bale is being formed. The pressure plate is opened and closed by two hydraulic rams 60 which are in an extended position when the pressure plate 59 is closed so as to restrain movement of the pressure plate 59 in response to pressure within the chamber 7. In other words, the pressure exerted by the rollers 16 in the formation of the bale 21 is partially transmitted to the pressure plate 59, which in turn pushes against the hydraulic rams 60, which control the pressure on the pressure plate.

The pressure plate 59 is rotatable about a bearing 61 located centrally of the support frame 54 (see Fig. 3). The pressure plate 59 is caused to rotate by the bale 21 as it rotates together with the chamber 7, during the formation of the bale 21.

As will be noted, particularly in Figures 1 and 2 and 4, the gantry 56 also supports a bale cutting device in the form of a band saw 64. The band saw 64 comprises an endless flexible saw blade 65, which is rotatable about rollers 66, 67, 68 and 69, and includes a transverse member 57.

The gantry 56 has inwardly directed legs 55 which carry wheels 62 on their ends (see Fig. 3). As shown in Figure 2 the wheels 62 run along longitudinal rails 63. In this way, the gantry 56 carrying the pressure plate 59, and the band saw 64, may move longitudinally of the chassis 4 by means of a pair of hydraulic rams 79, located one to each side of the machine. For example, the gantry 56 may move rearwardly from the position shown in Figure 1 to that shown in Figure 8.

The second wrapping station 3 is located to the rear of the chassis 4. It comprises a support platform 70 which is mounted on a trolley 71. The trolley 71 has wheels 72 which are caused to move along rails 73, by hydraulic rams (not shown). The trolley 73 may reciprocate from the rearward position shown in Figure 1 to a forward position shown in Figure 8, and back again, as will be described more fully below.

A pair of laterally spaced rollers 74 are mounted for rotation, about a horizontal axis, on the support frame 70. The rollers 74 are driven by a hydraulic motor through a freewheel or overrun coupling. An endless conveyor belt 75 is stretched between the

rollers and rotates with the rollers. The belt 75 moves transversely of the machine. The purpose of the conveyor belt is to rotate a formed bale 21 about its longitudinal axis during wrapping of the bale, in well known manner. The bale 21 is rotated in a direction opposite to the direction it was rotated during forming. The freewheel allows the rollers 74 to freely rotate when the bale is being formed, and the rollers 74 are in contact with the bale 21 as it is rotated by the rotating compaction chamber 7. When the bale 21 is cut and the belt table 75, with the bale in place, is moved to the rear of the machine, the rollers 74 are then powered by the hydraulic motor.

The means for wrapping the bale 21 at the second wrapping station 3 comprises a wrapping dispenser 81 containing a roll of plastics film in well known manner. This is carried by a support arrangement comprising a fixed gantry 82. The gantry 82 comprises a pair of uprights 80 mounted to each side of the chassis 4, and includes a pair of transverse members 85 which support the wrapping mechanism. A hydraulic motor 83 is mounted on the gantry 82 and drives a rotary arm 84 in a circular path around the wrapping platform 70. At least one film dispenser 81 depends downwardly from the end of the rotary arm 84. Preferably, as shown in the drawings, two film dispensers 41, disposed at 180° to each other, are carried one on each end of the rotary arm 84. These dispensers rotate in unison around the bale 21.

The film dispenser 81 is of well known construction and may include a pretensioning unit through which the plastics film is fed and stretched. The film dispenser may include a cut and start device for severing the film at the end of wrapping, e.g. of the kind shown in IE S80403.

In use of the machine of the invention, loose cut grass, silage, or other fodder is blown directly from a separate forage harvester, or preferably, by an integral harvester 93 (see Fig. 13) of the machine of the invention, into the compaction chamber 7 through the hopper 40, and by means of the rotating auger 41 (see Fig. 5). The auger 41 feeds the material through the feed inlet 8 from where it is swept around the sides of the chamber 7 by the rotating compaction head 15. If the auger is rotated counter to the rotation of the head 15 (as described with reference to Fig. 6) this has the advantage that the material is more evenly distributed around the chamber 7.

In the chamber 7 the fodder is compressed by the rotating compaction head 15. The compaction head 15 rotates, about the horizontal axis, around the inside perimeter of the chamber 7 with the cleated rollers 16 constantly rolling over the rear surface of the fodder as it is compacted and builds up in the chamber 7 to form a bale 21.

The horizontal movement of the pressure plate 59 is hydraulically restricted, and acts to exert a horizontally-directed force on the bale of fodder being formed so that efficient compaction of the fodder to a high density is achieved. The hydraulic ram pressure on the pressure plate 59 is adjustable either by means of the hydraulic rams 79 or by electro-hydraulic means. When a pre-set compaction pressure on the pressure plate 59 is achieved a signal is sent to retract the hydraulic rams 79 to move the pressure plate 59 rearwardly until the hydraulic pressure on the pressure plate 59 is again below the pre-set value, whereupon the rams 79 again press the pressure plate against the end of the partly-formed bale 21(see for example, Fig. 7). The rollers 16 press the fibres in the grass or other fodder to extract air from the fodder and to remove the "spring back" from the bale which is a problem with some conventional balers. Thus, when the bale is fully formed and the pressure plate 59 is moved rearwardly off the formed bale 21 there is very little springing back of the fodder and the bale retains its high density.

The sequence of the compacting and wrapping operation is shown in figure 2 and 7 to 13. Figure 2 shows the position of the components of the machine at the start of the compacting operation. The pressure plate 59 is held by the rams 79 against the outlet end 18 of the compaction chamber 7. The trolley 50 is positioned adjacent the outlet end 18, and the baling platform 70 is positioned rearwardly of the machine.

As the chamber is filled with fodder, by means of the auger 41, the compaction head 15 is operated to compact the material within the chamber 7 as described above. Simultaneously, the pressure plate 59 moves rearwardly, under pressure as described above. The partially formed bale 21 is extruded from the outlet end 14 of the chamber 7, as shown in Figure 7. The exposed portion of the partly-compacted bale 21 is supported on the rollers 53.

During the formation of the bale 21, the chamber 7 is constantly rotated as described above. Film 24 is drawn from the film dispenser 20 by rotation of the chamber 7, and is wrapped around the exposed cylindrical surface of the bale, as it rotates with the chamber 7. This is best shown in Figure 3, which shows the film 24 being drawn from the dispenser 20 by the rotation of the compaction chamber 7 in the direction of the arrow. The wrapped plastic film 24 overlaps the peripheral end of the chamber 7. As this is happening the pressure plate 59 rotates with the bale 21 and the chamber 7, also in the direction of the arrow in Figure 3. Inside the chamber 7, the compaction head 15 is rotating in the opposite direction. The film 24 also overlaps the exposed end of the bale adjacent the pressure plate 59. As the bale is extruded from the compaction chamber 7 it is wrapped in the film, which is spiralled longitudinally of the

bale. The film dispenser 20 has a limited range of longitudinal movement so that it can be moved to the desired position when the cutting is taking place.

As the bale 21 is extruded from the outlet end 18 of the compaction chamber 7, it is supported on the rollers 53, which take the weight of the bale and also partly support the chamber 7.

As shown in Figure 8, when the bale is almost fully extruded from the outlet 18 (e.g. when the extruded portion has a length of about 1200 mm) the wrapping platform 70, on trolley 71 is moved forward on the rails 73 until it makes contact with the trolley 50, which is pushed forward under the chamber 7. The compactor continues to extrude the bale 21, the extruded portion of which is continuously wrapped in film from the film dispenser 20 as described above. The extruded potion of the bale 21 moves from the rollers 53 onto the platform 70.

When the desired length of bale is fully extruded, (e.g. to a length of 1500 mm), the band saw 64 is signalled to operate. The saw blade 65 begins to rotate and the saw is moved downwardly on the gantry 56, by means of a hydraulic rams 76, to begin cutting through the extruded bale, and its plastics film wrapping, at a position immediately adjacent the outlet end 18 of the chamber 7. Because, the compaction chamber 7, and the partly formed bale 21, continue to rotate during the cutting operation, the saw blade 65 needs only to move down a distance slightly greater than half the diameter of the bale 21. During the cutting operation, the pressure plate 59 continues to press against the end of the bale 21.

When the bale 21 has been completely severed, by the band saw 64, from the remainder of the compressed fodder, or other material, within the compaction chamber 7, the saw blade 65 is raised, and the pressure plate 59 is also raised, to the position shown in Figure 9. The wrapping platform 70 on trolley 71 is then moved rearwardly to the second wrapping station 3.

The wrapping apparatus at the wrapping station 3 then begins to operate as shown in Figure 11. The wrapping dispensers 81 are rotated around the bale 21 in well known manner to complete the wrapping of the bale 21 with plastics film.

When the bale 21 is completely wrapped it is tipped from the wrapping platform 70 by tipping means as described below.

During the course of the wrapping of the bale 21 at the wrapping station 3, a new bale is in the course of compaction at the compaction station 1, as shown in Figure 11. Thus, the invention has the considerable advantage that the compaction operation is continuous, and does not have to be interrupted to allow for wrapping the bale.

The second wrapping station 3 may comprise wrapping apparatus of the kind described in EP 539549, for example, where the belt 75 has a substantial sag. Alternatively, the belt 75 could be replaced by an array of rollers for turning the bale.

In an alternative arrangement the belt 75 may be arranged on a rotary turntable with a fixed film dispenser, in well known manner.

When the bale is fully wrapped it is tipped from the endless belt 75 by a tipping mechanism as illustrated in Figure 12. As shown in this embodiment, a ram 86 causes the support frame 70 to pivot about a pivot 77. As the bale 21 is tipped rearwardly it comes in contact with a transverse pivot platform 88. This is supported and held in place by two arms 87 which are pivoted to the chassis 4. The downward movement of the arms 87 is restricted by two hydraulic accumulator rams 89. As the weight of the bale 21 comes onto the pivot platform 88 it causes the arms 87 to swing down onto the ground, as shown in broken lines in Figure 14, against the bias of the rams. The bale 21 is thus lowered gently onto the ground. The forward movement of the machine pulls the pivot platform 88 from underneath the stationary bale 21, and the arms 87 are then raised by the rams 89 to their upper position. The inner ends of the arms 87 are pivotally connected to brackets, one on each side of the machine. The free outer ends of the arms 87 are pivotally connected to the respective ends of the pivot platform 88. The platform 88 is pivotally connected to the arms 87 intermediate its width so that it is freely rotatable between the arms.

The tipping device of the invention has the advantages that it enables the wrapped bale, which is heavy, to be lowered gently onto the ground. This is important because if the bale is not gently dropped the wrapping may be punctured by stalks or stones. The tipping device is designed so that it can deposit the bale on the ground either lengthways or on its end.

In another embodiment (not shown) a conventional forage harvester, for example of the type marketed under the tradename "Tarup", or model "FCT850" as sold by J.F. Farm Machinery is used in conjunction with the machine of the invention. Grass, or other suitable forage crop, is cut in the field by a mower and left to wilt for a day or so.

The forage harvester, which is towed by a tractor, picks up the cut grass (silage), precision cuts the silage into short lengths and blows the chopped silage through the inlet 40 of the compacting station of the invention. The precision cut silage is then baled and wrapped as hereinafter described. With this arrangement the forage harvester travels in tandem with the machine of the invention.

It will be noted that the bale 21 has been formed without the use of twine or cord to keep it from falling apart. Because the transfer of the bale 21 from the compacting station to the second wrapping station is effected after partial wrapping at the first wrapping station the integrity of the bale is maintained. The first wrapping of the bale at the first wrapping station suffices to hold the bale together. However, if rotation of the bale were to be effected to achieve wrapping, as in a conventional wrapping machine, it is likely that the bale would fall apart at this stage.

Other modifications may be made to the machines described above. For example, the compaction chamber 7 could be non-rotatable, in which case the pressure plate 59 need not be rotatable. In that event means would be provided to rotate the film dispenser 20 around the bale 21 as it is extruded from the chamber 7.

In the above description, the compacting chamber is of cylindrical shape to produce cylindrical bales 21. However, it will be appreciated that different shaped compacting chambers may be used, e.g. rectangular or square shaped. In that case, the second wrapping station may be adapted to wrap square bales e.g. by incorporating the invention of EP 539549 and IE S970777

The machine of the invention may be used either as a stationary machine to which the fodder is transported for compacting, baling and wrapping. Alternatively, it may be mobile so as to move around the field picking up the cut grass or other fodder, baling and wrapping it as it moves. Thus, the machine of the invention may have a pick up and chopper system fitted to it or it may be fed by a tractor drawn silage harvester working alongside. Alternatively in the stationary position the grass may be picked up and chopped in the field with a tractor drawn silage harvester and brought to the parked machine in a bulk silage station. The machine would then require either a tractor and loader or have its own self loading arm fitted to load the loose silage and to lift off and stack the wrapped bales.

A further embodiment of the invention is shown in Figure 13. This is a self-propelled mobile version of the machine having an integral harvester. The compacting

and wrapping apparatus is as described above and like parts have like numerals. In this arrangement the chassis 4 is more substantial than in the previous embodiment and includes two pairs of wheels 5. A cab 90 is built on the chassis forward of the compacting station 1. An engine 92 is located beneath the cab 90. A silage harvester 93 is mounted forwardly of the cab 90. The silage harvester has a chute 9 which directs the cut silage into the inlet hopper 40 of the compaction chamber 7.

A further embodiment of the compacting and wrapping machine of the invention is shown in Figures 14 to 16. The difference between this embodiment and the embodiment of Figure 1 lies in the construction and operation of the band saw 64. In this embodiment the band saw 64 is replaced by an endless saw 95.

As shown, for example in Figure 16, the saw 95 comprises an endless flexible, and toothed , saw blade 96, which rotates about a first drive roller 97 located at one side of a saw blade backing plate 101, and about a second drive roller 98 at the opposite side of the backing plate 101. The saw blade 96 also travels about idler rollers 99 and 100 which maintain tension on the blade 96. The drive rollers 97, 98 are driven by motors 102, 103 which may be hydraulic or electric motors. It will be noted from Figure 16 that when the drive rollers 97, 98 are driven the endless blade 96 is caused to move in opposite directions in the cutting location. Thus, during the cutting operation two parts of the blade, spaced a short distance apart, are simultaneously cutting in two opposite directions. This provides for a faster and more improved cutting operation.

The backing plate 101, carrying the saw 95 is mounted on a wheeled gantry or carriage 104 which is moveable, horizontally of the machine, along the rails 63 by means of a hydraulic ram 105, in a manner similar to that described with reference to Figures 1 and 2.

The saw 95 and the backing plate 101 are moveable vertically in guides on the gantry 104 by means of the hydraulic rams 76.

As described with reference to the first embodiment, when the desired length of bale is fully extruded, the saw 95 is signalled to operate. The saw blade 96 begins to rotate and the saw and backing plate 101 are moved downwardly on the gantry 104, by means of the hydraulic rams 76, to begin cutting through the extruded bale, and its plastics film wrapping, at a position immediately adjacent the outlet end 18 of the chamber 7. Because, the compaction chamber 7, and the partly formed bale 21, continue to rotate during the cutting operation, the saw blade 96 needs only to move

down a distance slightly greater than half the diameter of the bale 21. During the cutting operation, the pressure plate 59 continues to press against the end of the bale 21.

However, because in this embodiment, the cutting device 95 is mounted on its own moveable gantry 104, it can move forwardly and rearwardly of the machine independently of the pressure plate. 59. Thus , the blade together with the backing plate 101 can remain in a lowered position while the pressure plate 59 is raised as described in the embodiment of Figure 1. The backing plate presses on the cut surface of the material in the compaction chamber 7, thus permitting the making and extruding of a new bale as the previous bale is being transferred to the second wrapping station 3. When the pressure plate 59 is moved back into position the blade 96 and backing plate 101 are raised. The process then continues as previously described.

Further alternative embodiments of cutting devices are illustrated in Figures 17 to 19. In these arrangements the saw comprises a chain saw 195, of the type commonly used as a wood saw, but with modifications in the overall shape, and in the tooth profile.

As shown in Figure 17, one embodiment of a chain saw 195 comprises an endless toothed chain saw blade 196 which is mounted on a backing plate 197. The saw is shown in broken line in the raised position, and in full line in the downward position. The saw blade is mounted for rotation on a bar, which is attached to and in line with the backing plate 197. The saw blade rotates about the bar in well-know manner. The backing plate 197 is of substantially rectangular shape, and is pivoted to one side of the machine frame at pivot point 198. The backing plate is pivotable, by means of a hydraulic ram (not shown) from the raised (inoperative) position, shown in broken lines, in the direction of the arrow, to a lower operative position, during which it cuts through the bale 21, as previously described.

Suitably, the saw-blade is driven on the bar 196 by a hydraulic motor mounted adjacent the pivot 198. The saw blade 196 has a tooth profile of the kind suitable for cutting through straw, for example a vertical sharp-edged profile.

In the embodiment shown in Figure 18, the backing plate 197 is of substantially circular or ovoid shape, that is the end which pivots on pivot 198 is more pointed than the remainder. Again, the backing plate 197 comprises two parallel plates which define a peripheral channel in which the saw blade 196 runs. In this embodiment the chain saw blade 196 travels around the whole periphery of the backing plate 197.

In the embodiment shown in Figure 19, two saws 195 are provided, each forming a segment of a circle in plan. Each saw blade 196 is mounted on a saw bar carried by the backing plate, similar to the arrangement of Figure 17. Each of the saws 195 is pivotally mounted on pivots 198, arranged side by side, at the top of the machine, and are moved by hydraulic rams, from the raised positions, shown in broken line, downwardly through the bale 21, to the positions shown in solid line. This embodiment has the advantage, that in the raised position, the saw segments do not protrude from the machine as far as do the saws 195 in the embodiments of Figures 17 and 18.

In all three embodiments, the saw 195 is mounted on a moveable gantry as previously described.

The machine of the invention may also include an integral forage harvester. The forage harvester may be detachably secured to the front of the machine in well known manner. Thus, the forage harvester could be unhooked from the machine of the invention for use for other purposes. Also the machine of the invention may include a trailer connected to the rear of the machine so that the fully wrapped bales may be tipped directly onto the trailer instead of onto the ground.

The machine and method of the invention has a number of advantages over existing bale wrapping system, for example:

(1) The new machine and method handles much shorter grass than conventional machines, this is a big advantage when the silage is incorporated into a diet using a diet mixer machine. The shorter material makes a much more homogenous mix.

(2) The system of the invention will handle maize silage. At present maize silage can only be made in a pit as conventional balers and wrappers cannot handle it. Indeed the invention enables the baling of all fine particulate material, e.g. precision chopped material of a particle size or length or from 15 to 50 mm. Previously, it has been difficult to bale such materials.

(3) No twine is required on the bales and so they are much easier to feed. It is very time consuming with the conventional system to cut the twine off bales before feeding.

(4) The baler system of the invention produces very high density bales, for example up to twice the density of existing soft centered bales. This reduces the cost of plastic per unit weight of silage by as much as 50%. This makes bale wrapping far more cost effective so that it can compete on cost with pit silage. It is also more environmentally friendly because there is less used plastic to dispose of.

(5) The invention requires less plastics per bale because of the improved wrapping technique. With prior bale wrappers the ends of the bale have far more layers of film than the circumference of the bale. With the technique of the invention the circumference of the bale is wrapped first then the ends so in this way the unnecessary extra layers of plastic on the ends of the bales are reduced.

(6) The baling system of the invention, with its rotating cleated rotors, presses the grass much more than existing balers. This pressing or conditioning helps to hold the sugars in grass, thus maintaining its feeding value during storage.

(7) It is possible to make different length bales on the machine of the invention with very little adjustment. In this way a contractor can make bales to suit the requirement of the individual farmer. Most conventional balers have fixed chamber so they can only make on size of bale.

(8) A particularly important advantage of the machine and method of the invention is that they permit the transfer of the compacted bale from the compactor to the second wrapping station without the need for secondary containment means such as cord, twine, netting or the like. The preliminary wrapping of the bale at the first wrapping station, including the overlapping of the corners, enables the bale to be transferred without breaking up.

(9) The compaction of the bales is a continuous operation and compaction need not be interrupted during wrapping of the bale.

(10) The band saw, which severs the individual bales, leaves a clean flat surface on the ends of the bale in contrast to conventional machines in which the ends of the bale may have a domed or irregular surface.

(11) The machine of the invention reduces significantly the manpower and number of machines needed to produce silage and other fodder. Currently, the most economic method of making silage is by harvesting the silage grass in the field and storing it in a large pit which, when full, is covered by heavy plastics sheeting. In making pit silage, the grass is first cut by one man by means of a large tractor and mower. The grass is allowed to wilt on the ground and then must be turned by one man using a tractor and tedding machine. This is followed by a five man team to harvest the wilted silage, using 1 harvester, 3 large tractors, 3 trailers, and 1 loader to load the silage into the pit. Not only is this a very expensive operation, but because it utilises many heavy machines it causes considerable damage to soil structure and farmyard surfaces. Using the machine of the invention as illustrated in Figure 13, one man and one machine can completely harvest and store the silage in large wrapped bales. The machine of the invention is suitable for cutting grass at a later stage of growth, when the moisture content is lower, thus obviating wilting. Because the density of the compacted silage is higher in bales produced by the invention than with conventional bale wrapped or pit silage, a higher quality of fodder is achieved.

From the foregoing, it will be apparent that numerous modifications and variations can be effected without departing from the true spirit and scope of the novel concept of the present invention. It will be appreciated that the present disclosure is intended to set forth exemplifications of the invention which are not intended to limit the invention to the specific embodiments illustrated. The disclosure is intended to cover by the appended claims all such modifications as fall within the scope of the claims.

Where technical features mentioned in any claim are followed by reference signs, these reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the scope of each element identified by way of example by such reference signs.

CLAIMS

1. A compacting and wrapping machine for compacting material into bales and wrapping the bales in wrapping film, comprising a compaction chamber having an inlet at one end and an outlet at the opposite end, compaction means within the compaction chamber for compacting material fed into the inlet end, and extruding compacted material from the outlet end, wrapping means located at the outlet end of the chamber for wrapping extruded material in wrapping film, wherein the axis extending from the inlet end to the outlet end of the compaction chamber is substantially horizontal, and means are provided for rotating the compaction chamber about said substantially horizontal axis during compaction of material within the chamber.

2. A compacting and wrapping machine for compacting material into bales and wrapping the bales in wrapping film, comprising a compaction chamber having an inlet at one end and an outlet at the opposite end, compaction means within the compaction chamber for compacting material fed into the inlet end, and extruding compacted material from the outlet end, wrapping means located at the outlet end of the chamber for wrapping extruded material in wrapping film, wherein the chamber is horizontally oriented and has a pressure plate located at the outlet end of the chamber and includes pressure means for pressing the pressure plate against the material as it is extruded from the chamber.

3. A machine as claimed in Claim 1, wherein a pressure plate is located at the outlet end of the chamber.

4. A machine as claimed in any of the preceding claims, wherein cutting means is provided at the outlet end of the chamber to cut the extruded material into discrete bales.

5. A machine as claimed in any of the preceding claims which includes a second wrapping station having a wrapping platform which is moveable from a position adjacent the outlet end of the compaction chamber, to a second position at said wrapping station, the wrapping platform being adapted to receive a compacted and partially wrapped bale at the outlet end of the compaction chamber and conveying the bale to the second wrapping station for the completion of the wrapping .

6. A machine as claimed in Claim 5, wherein the wrapping platform is mounted on wheels which run on rails extending longitudinally of the machine.

7. A machine as claimed in any of the Claims 2 to 6, wherein the pressure plate is moveable longitudinally of the machine.

8. A machine as claimed in any of Claims 3 to 7, wherein the pressure plate and cutting means are mounted on a gantry which is moveable longitudinally of the machine.

9. A machine as claimed in any of the preceding claims, wherein an auger is located at the inlet end of the compaction chamber to feed material into the chamber.

10. A machine as claimed in any of the preceding claims, wherein a moveable trolley is located at the outlet end of the compaction chamber to support the compacted material extruded from said outlet end.

11. A machine as claimed in nay of the preceding claims, where the compaction means comprises a rotating compaction head including at least one roller rotatable against the loose material within the compaction chamber.

12. A machine as claimed in any of the preceding claims, wherein the wrapping means located at the outlet end of the chamber comprises a rotatable film dispenser mounted adjacent the outlet end such that when film from the dispenser is attached to an end portion of the chamber, rotation of the chamber causes the film to be unrolled from the film dispenser to wrap around an exposed part of the compacted partially-formed bale as it emerges from the outlet end of the chamber.

13. A machine as claimed in any of claims 4 to 12, wherein the cutting means comprises a flexible endless saw blade mounted for rotation on a backing plate, and the saw and backing plate are moveable vertically during cutting.

14. A machine as claimed in any of the preceding claims characterised in that it includes an integral forage harvester or cutting machine.

15. A method of compacting and wrapping materials wherein the method includes the following steps:

a) feeding the material to be compacted into one end of a compaction chamber of a compactor;

b) rotating a compaction head against the loose material within the compaction chamber, to compress the material into a bale and extruding the bale from an outlet end of the chamber;

c) wrapping an exposed part of the partially-formed bale at a first wrapping station located at the outlet end of the compaction station, with a strip of wrapping material sufficient to maintain the integrity of the bale, without the need for cord, twine, or the like, cutting the extruded and partially wrapped bale to a desired length; and

d) transferring the partially-wrapped bale to a second wrapping station where wrapping of the bale with a film of wrapping material is completed.

16. A method as claim in claim 15, wherein pressure is exerted on the end of the partially-formed bale emerging from the outlet end of the compaction chamber by means of a pressure plate which is urged against said end.

17. A method of compacting and wrapping particulate material, particularly chopped maize, characterised in that it comprises the steps set out in any of claims 15 or 16.

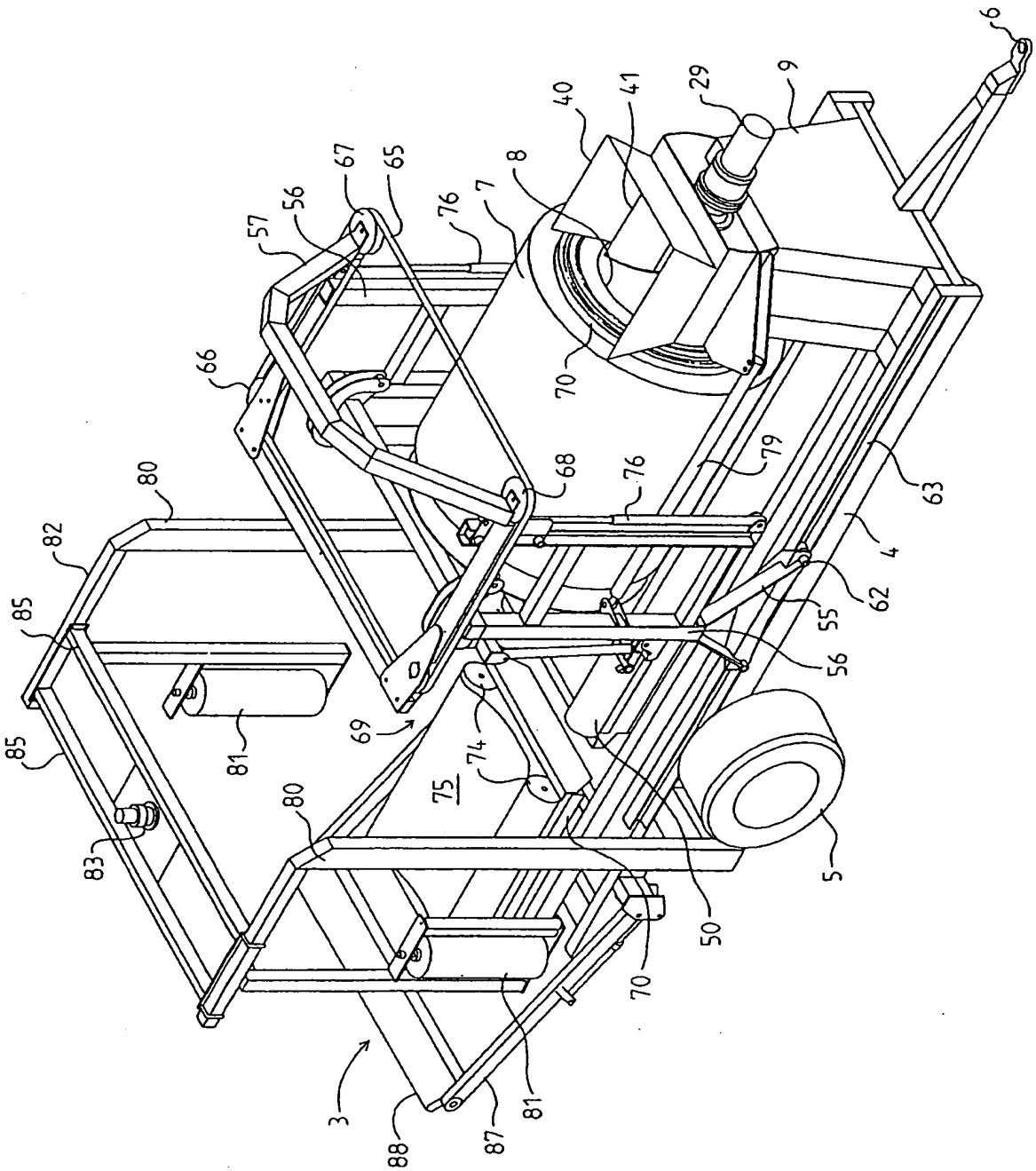
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Fig 1

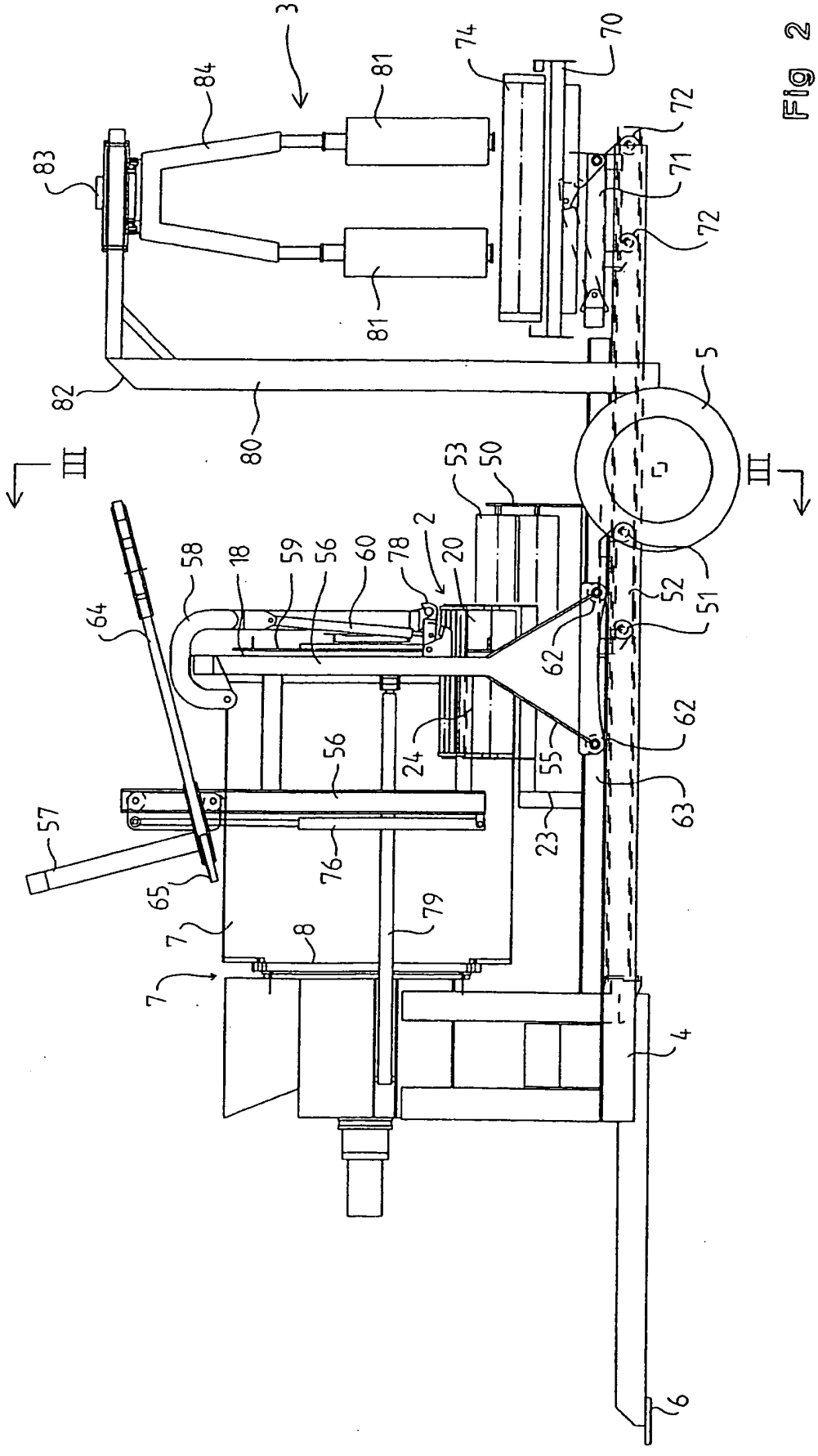
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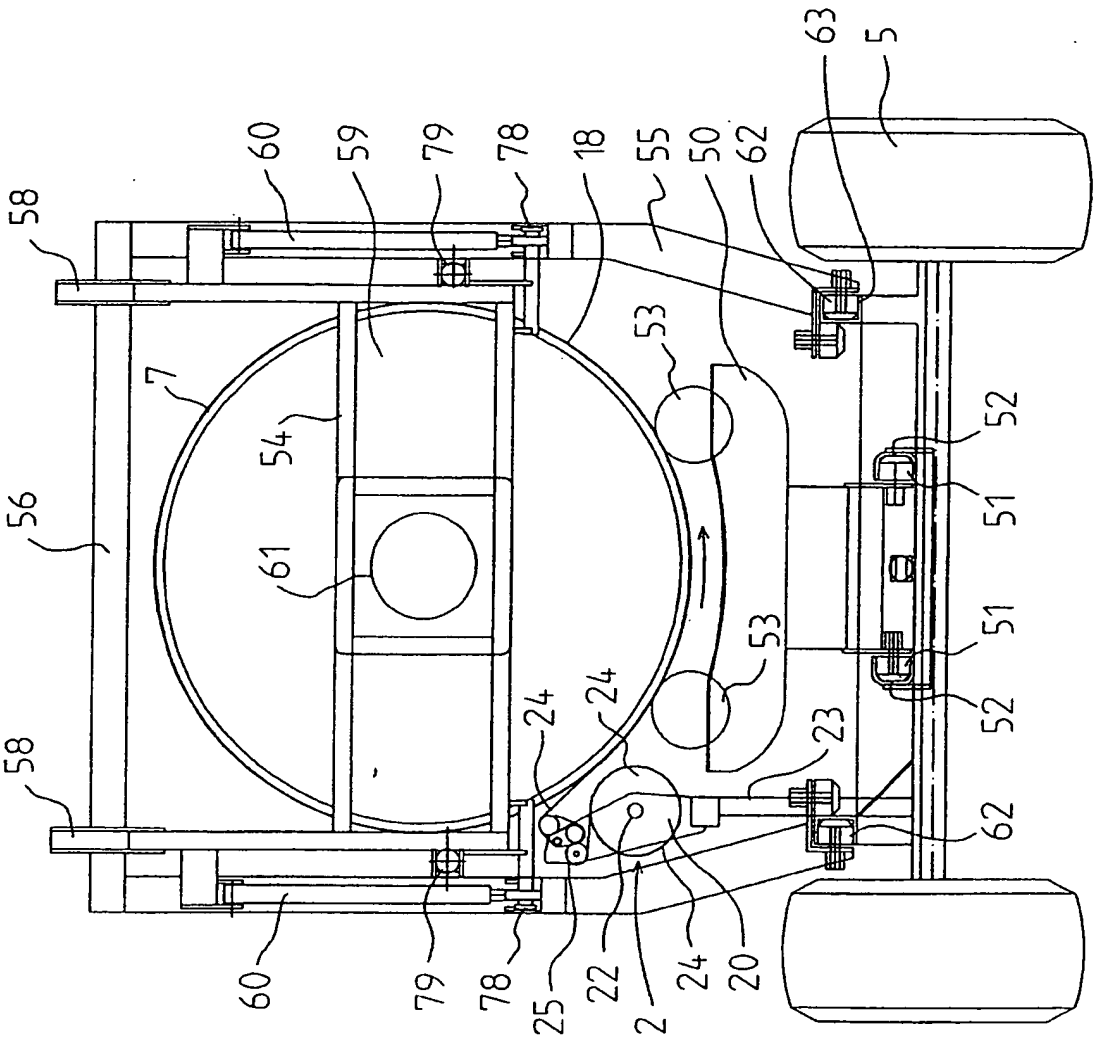
Fig 2

Fig 3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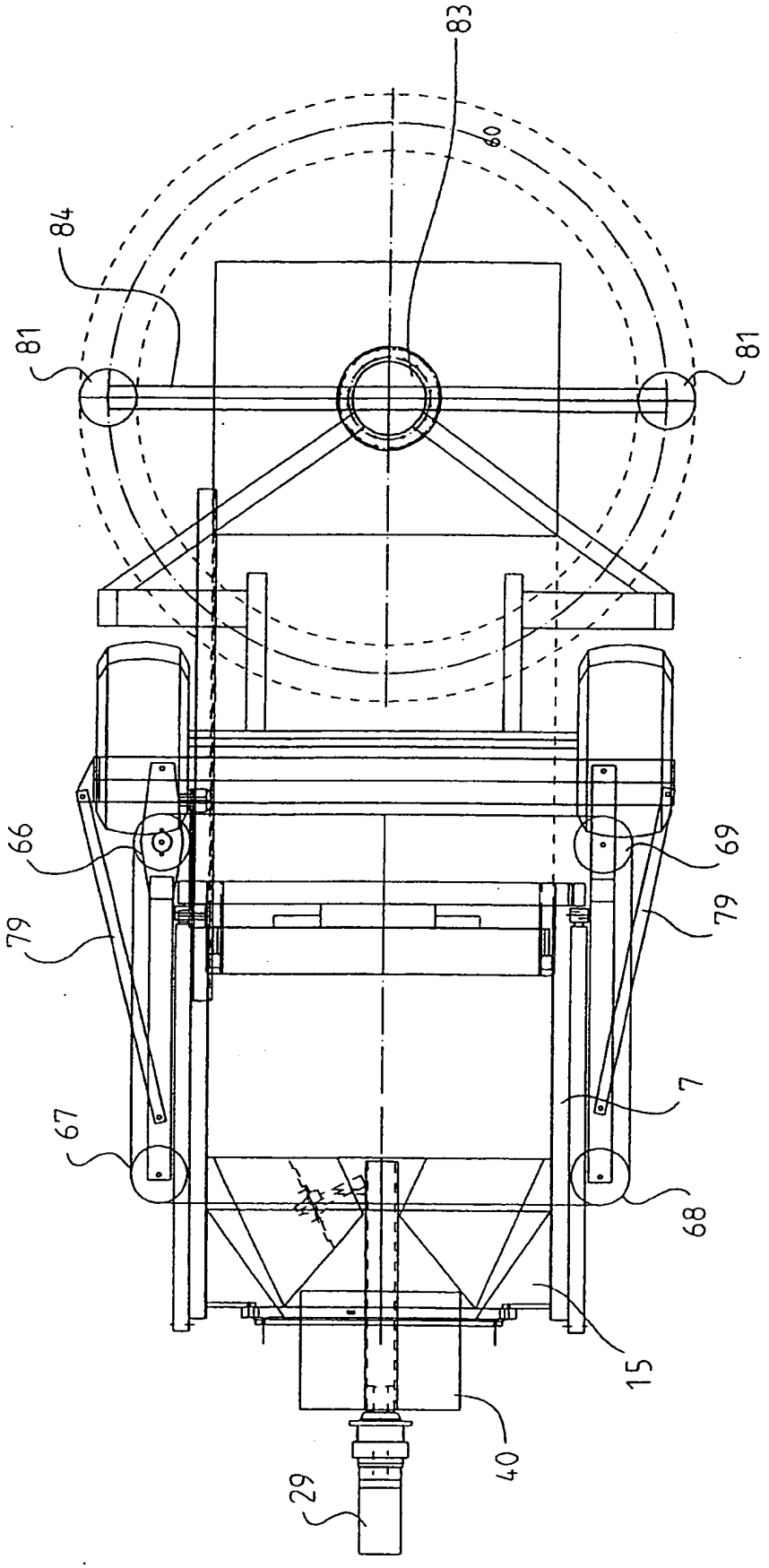
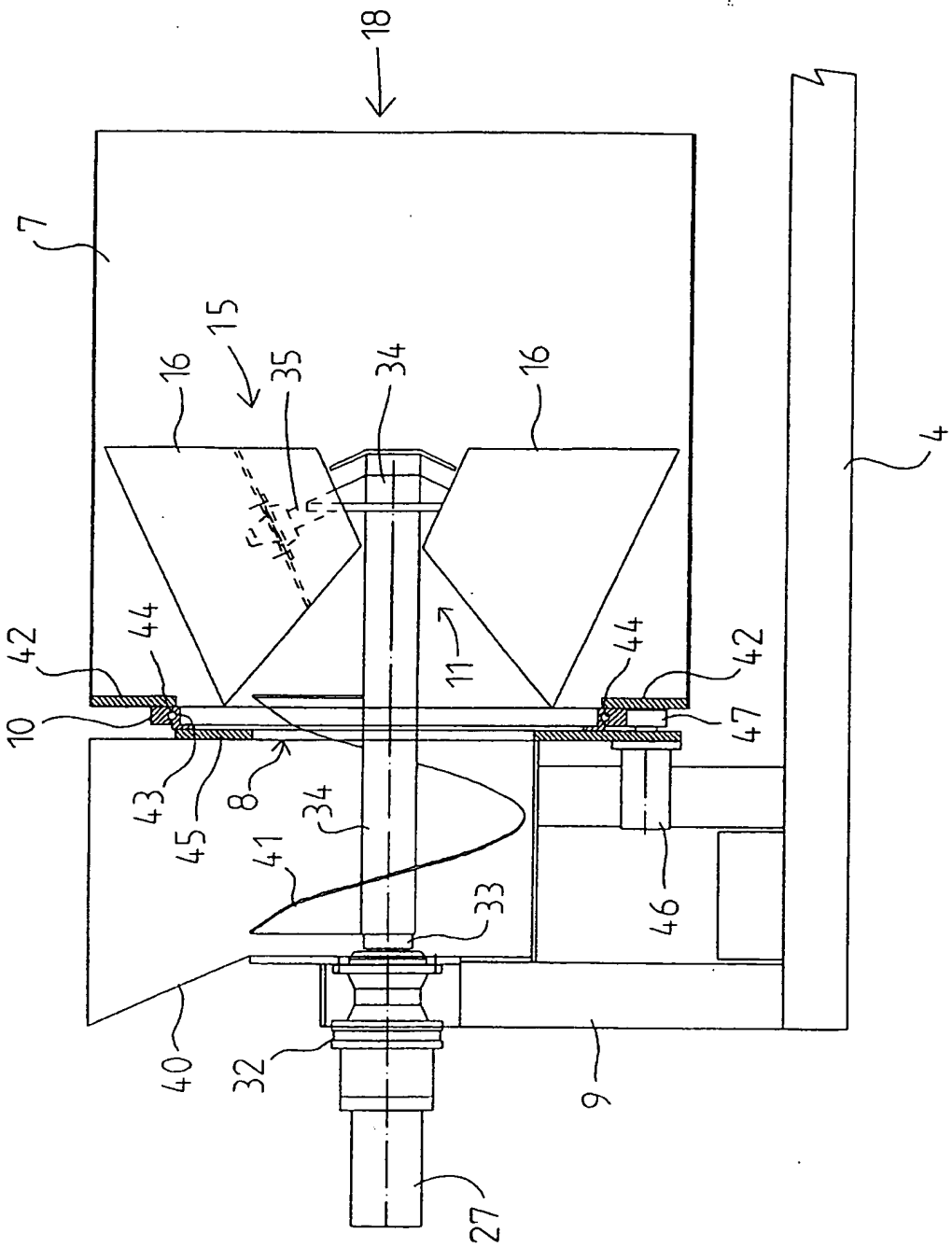


Fig 4.

Fig 5



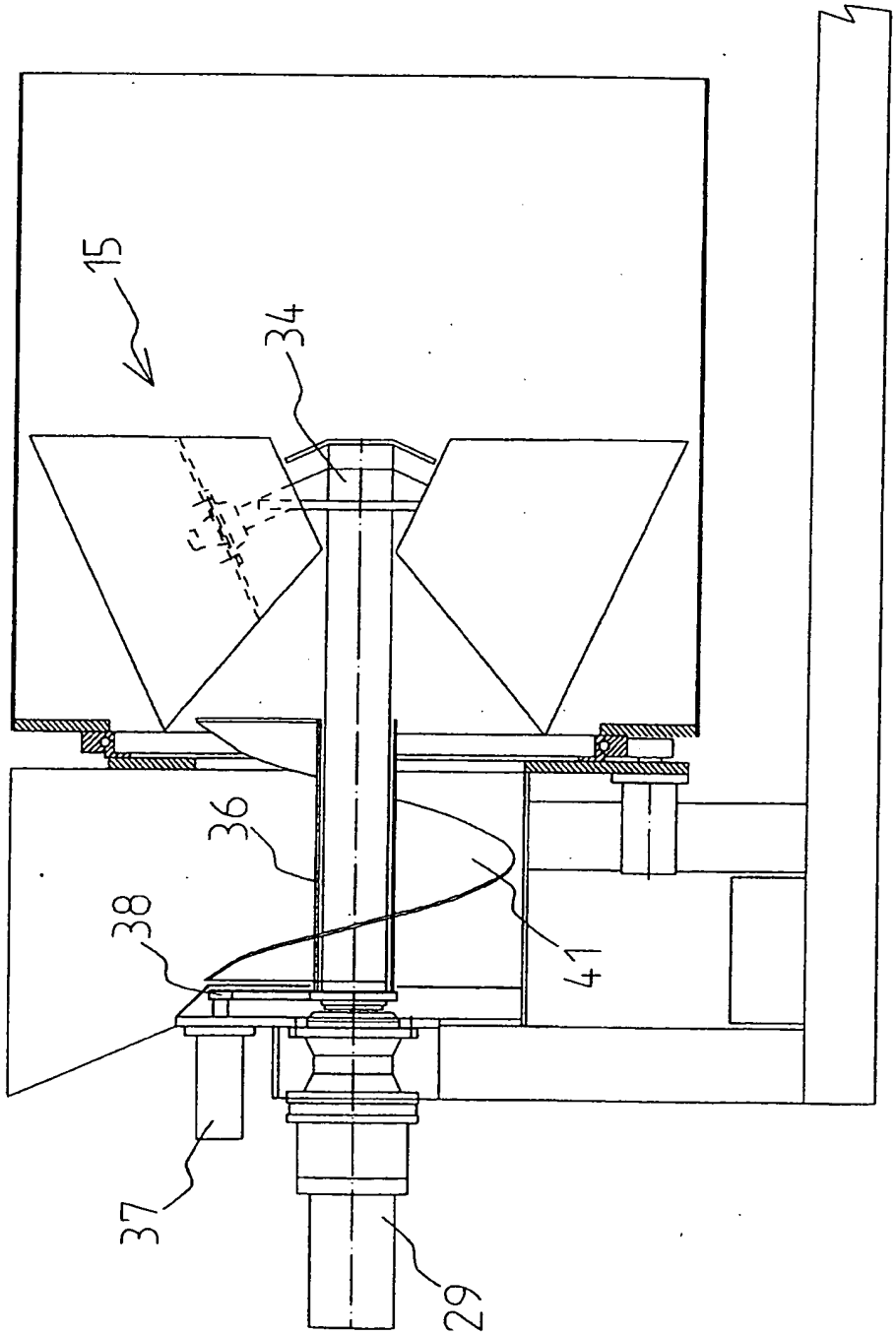


Fig 6

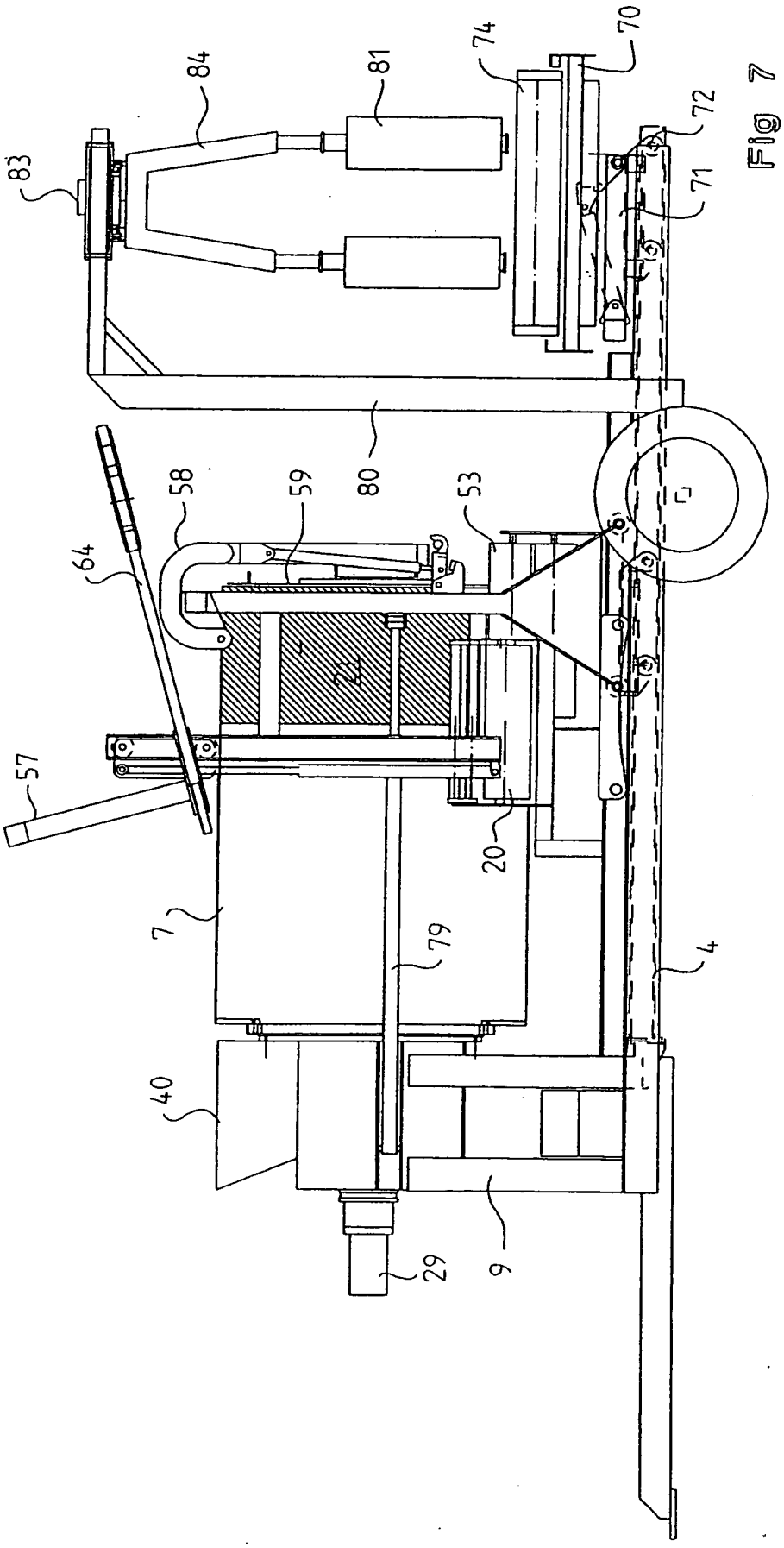


Fig 7

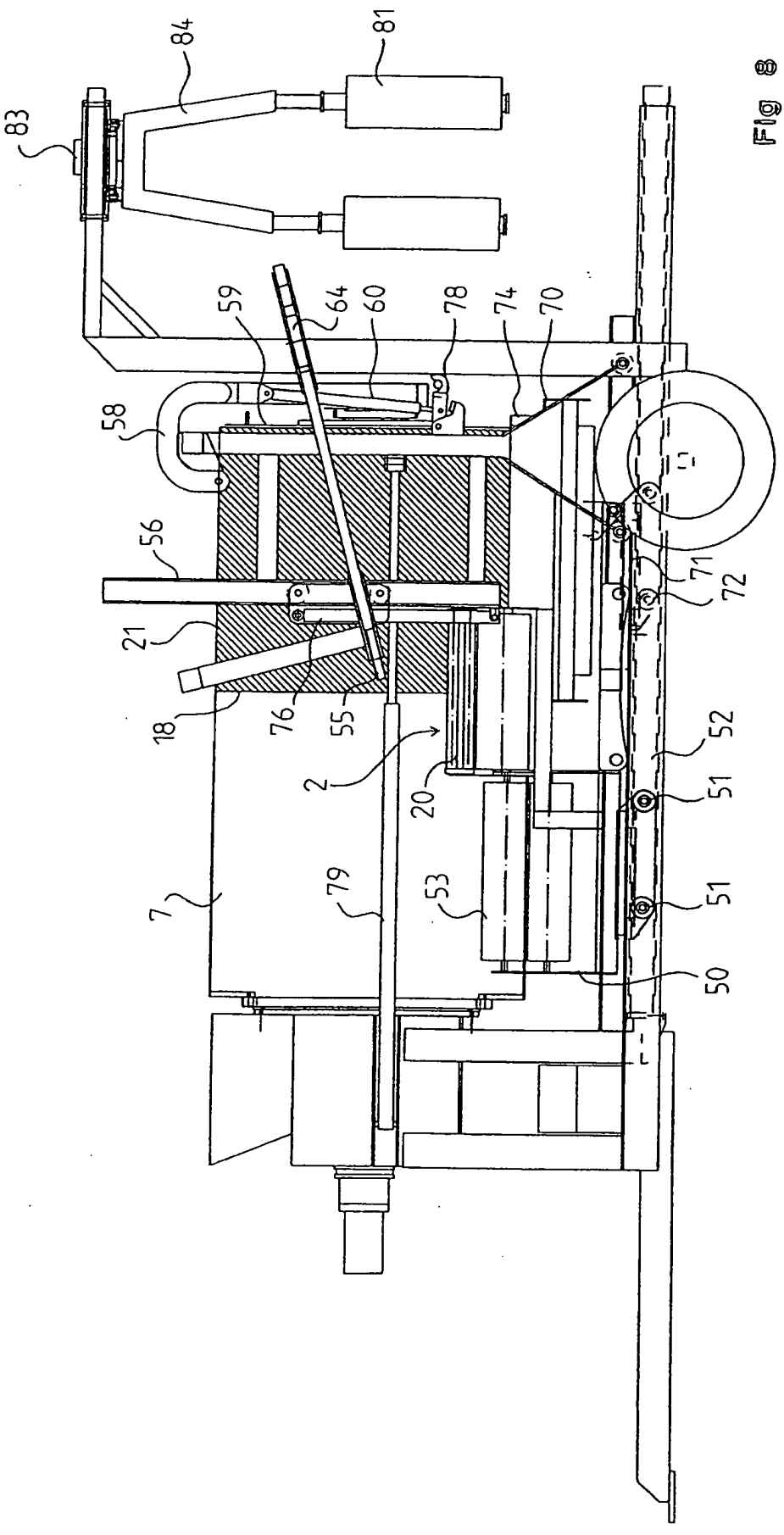

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Fig 8

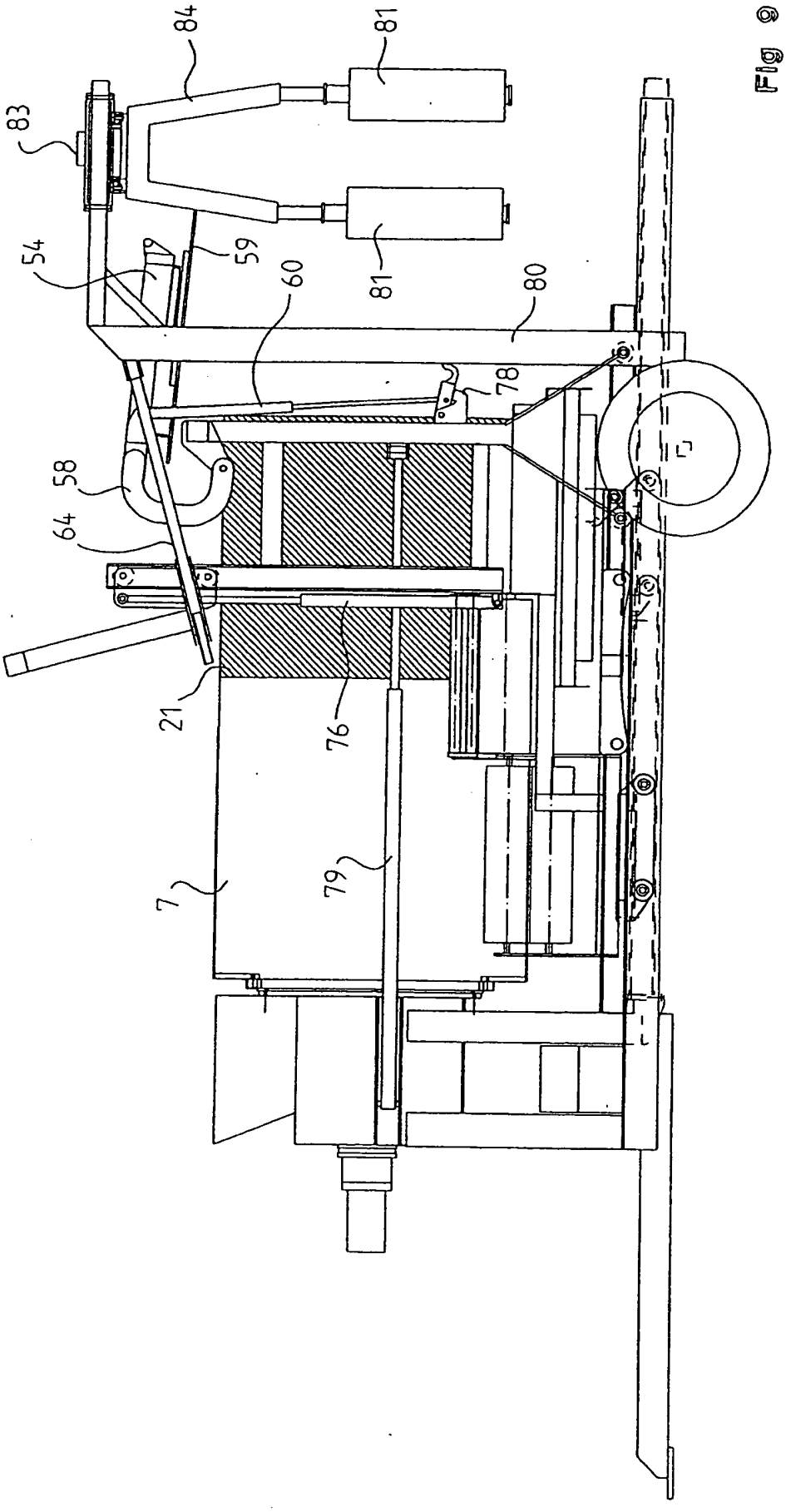


Fig 9

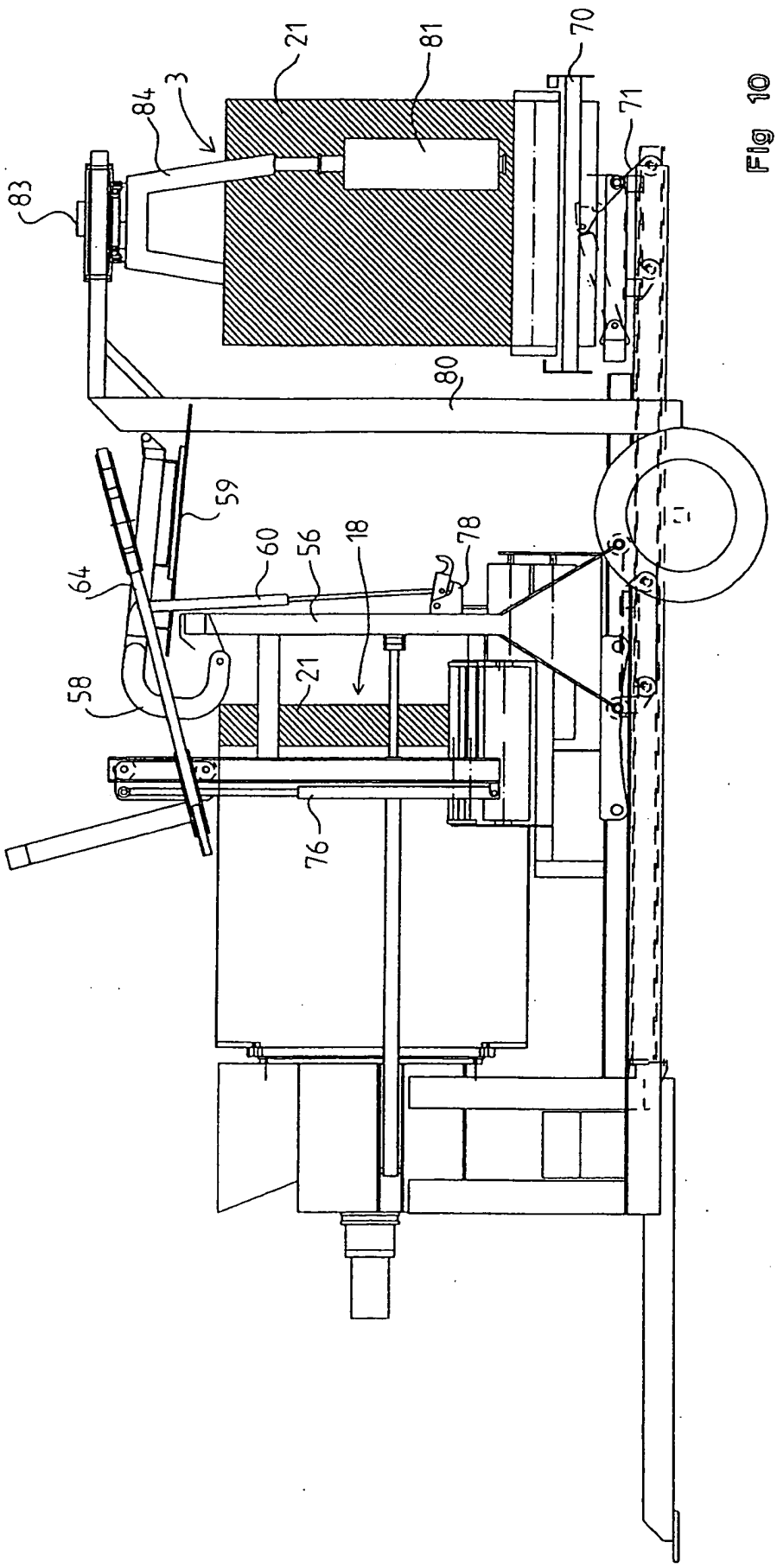


Fig 10

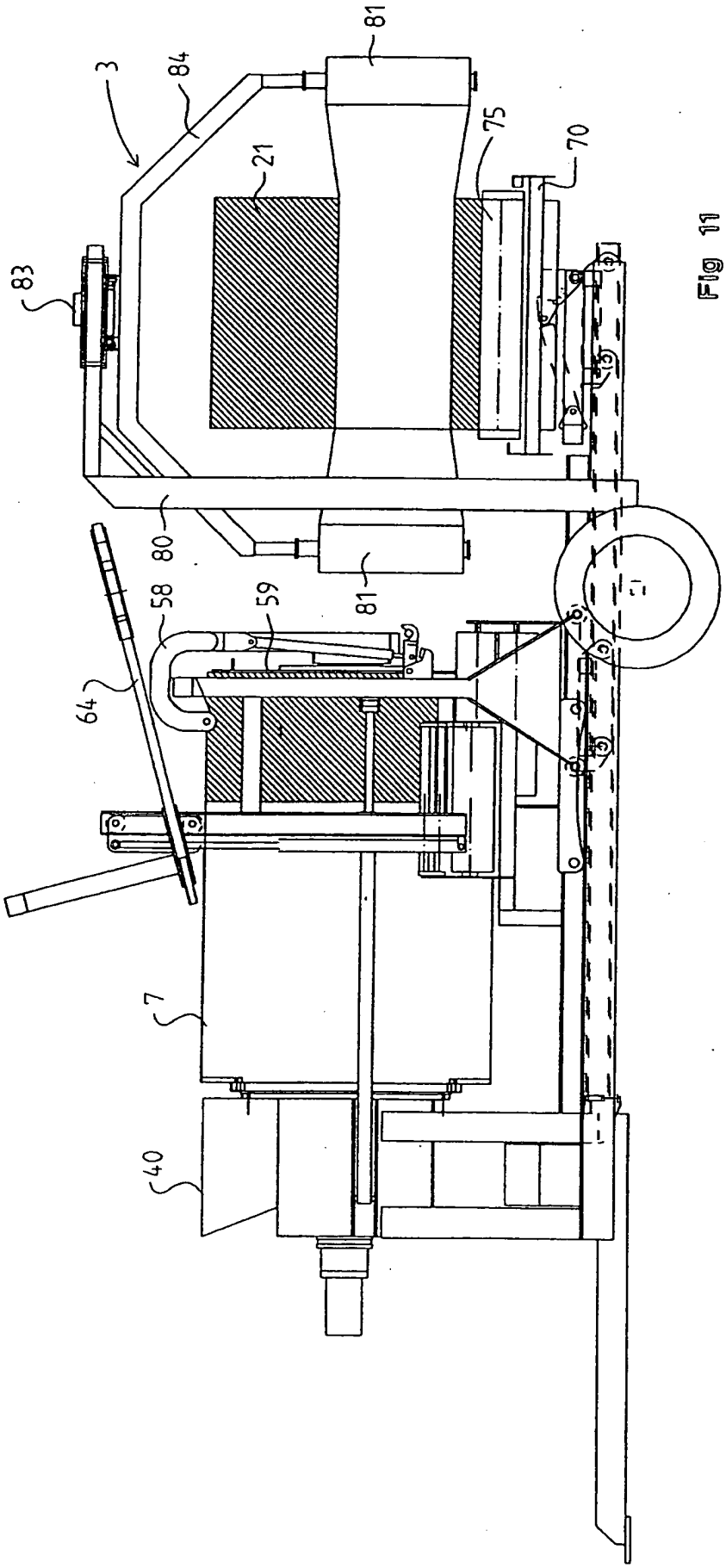


Fig 11

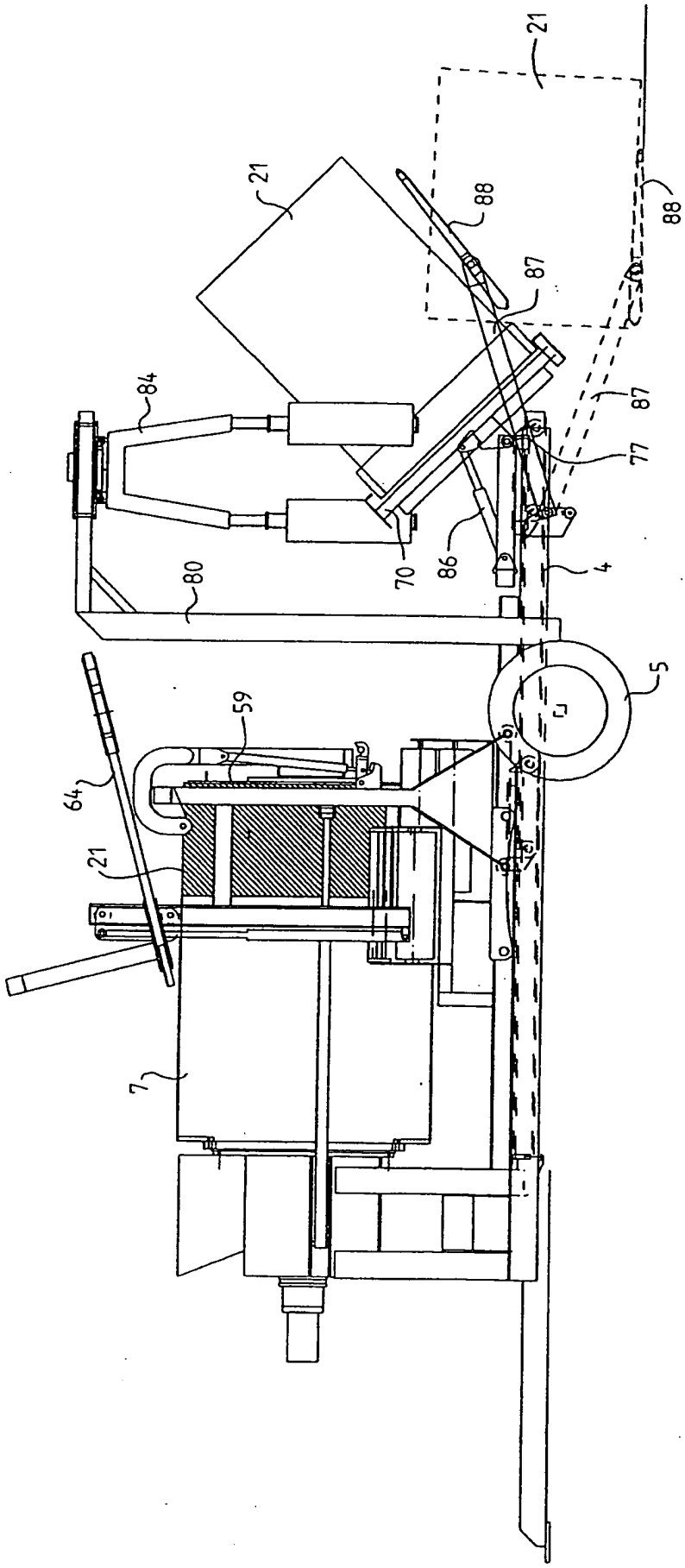


Fig 12

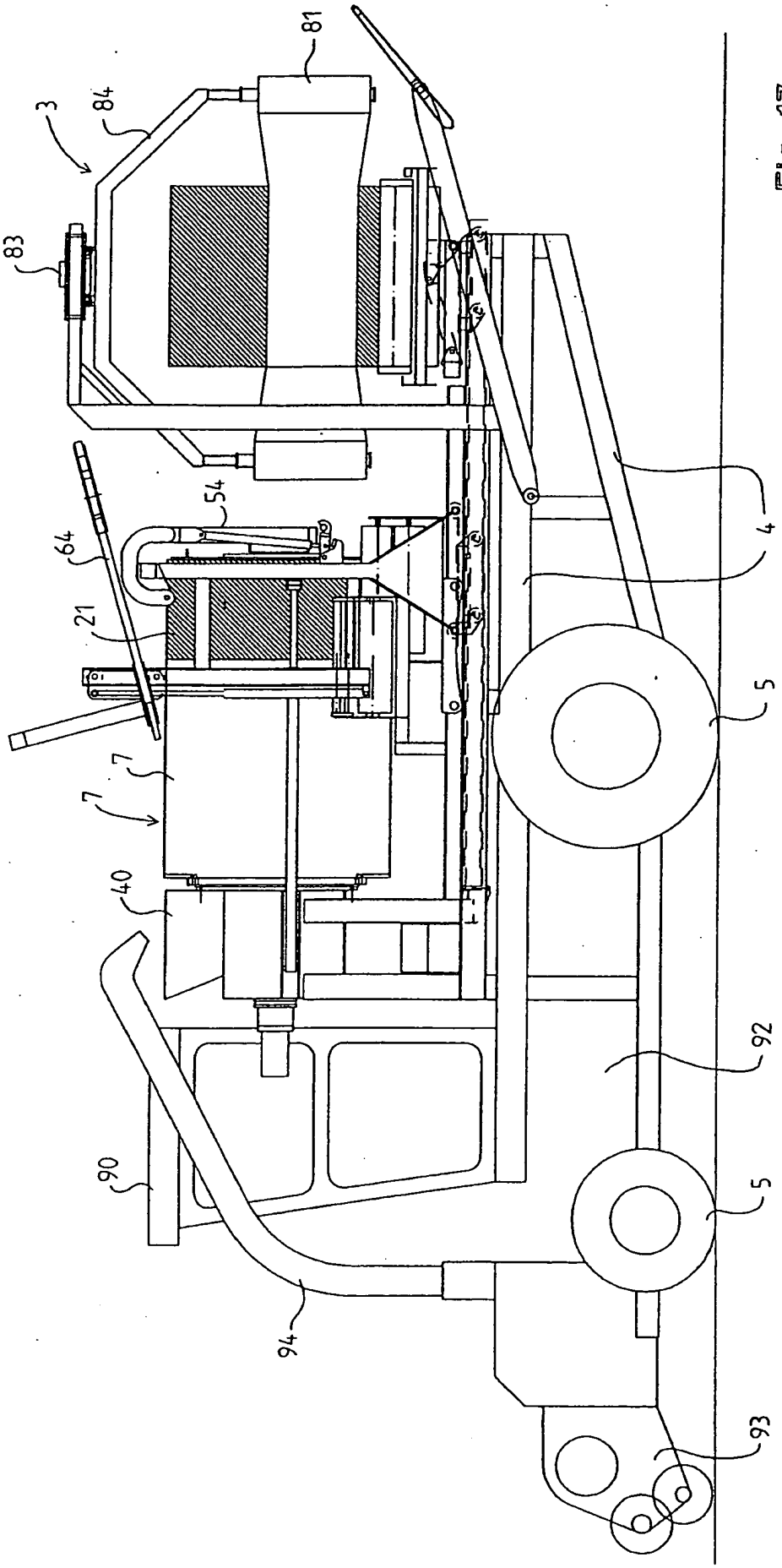
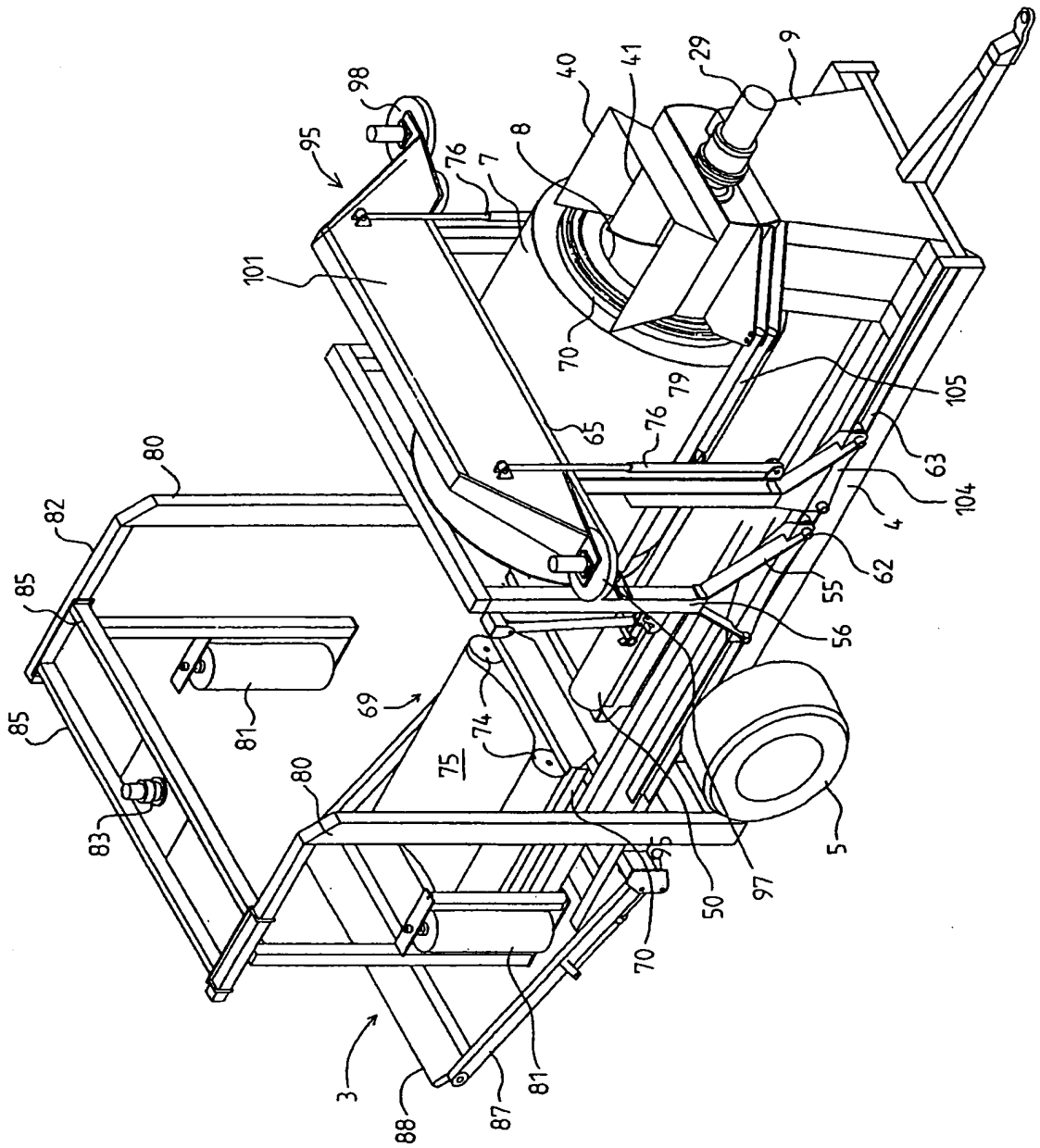


Fig 13.

Fig 14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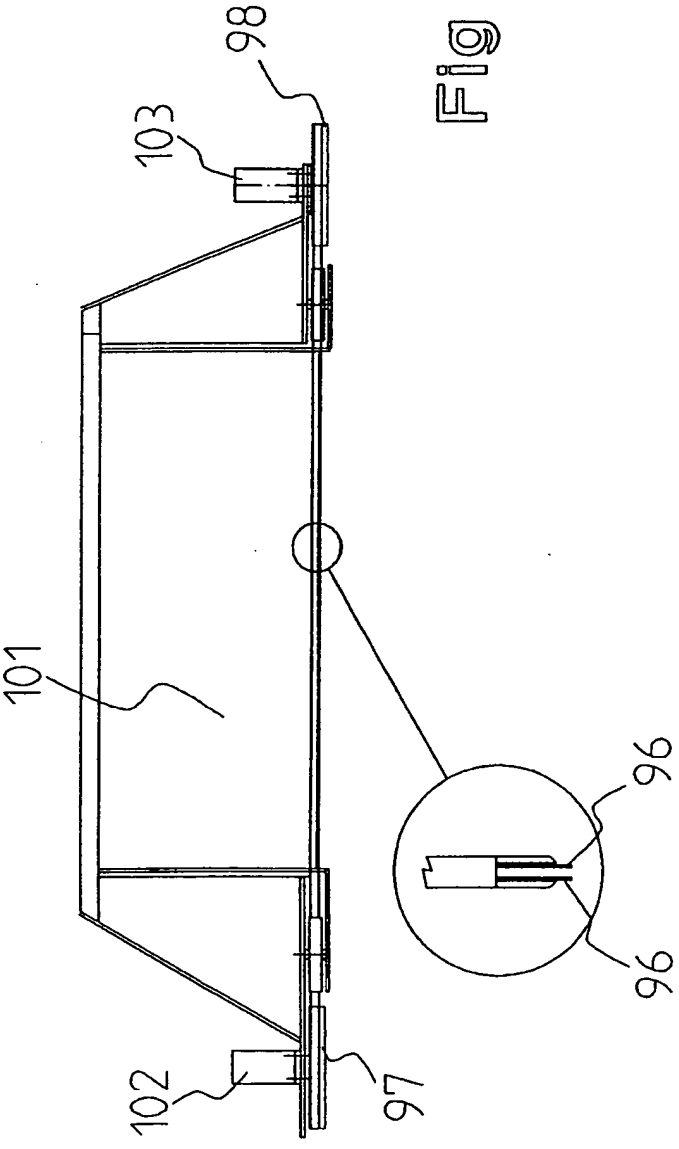
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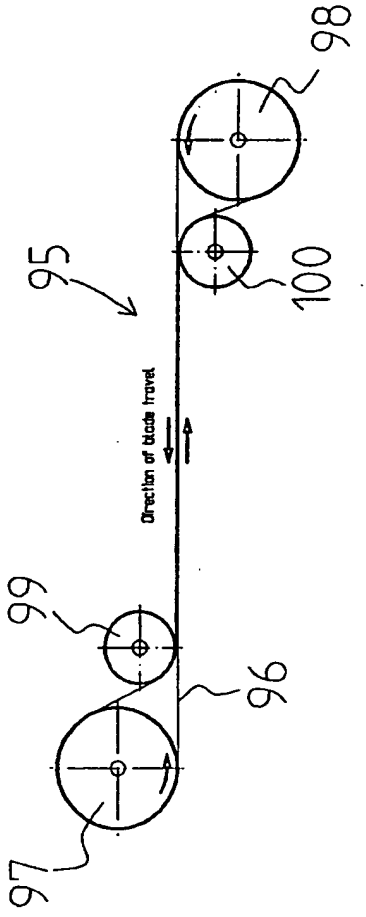
Fig 15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Direction of blade travel
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Fig 16

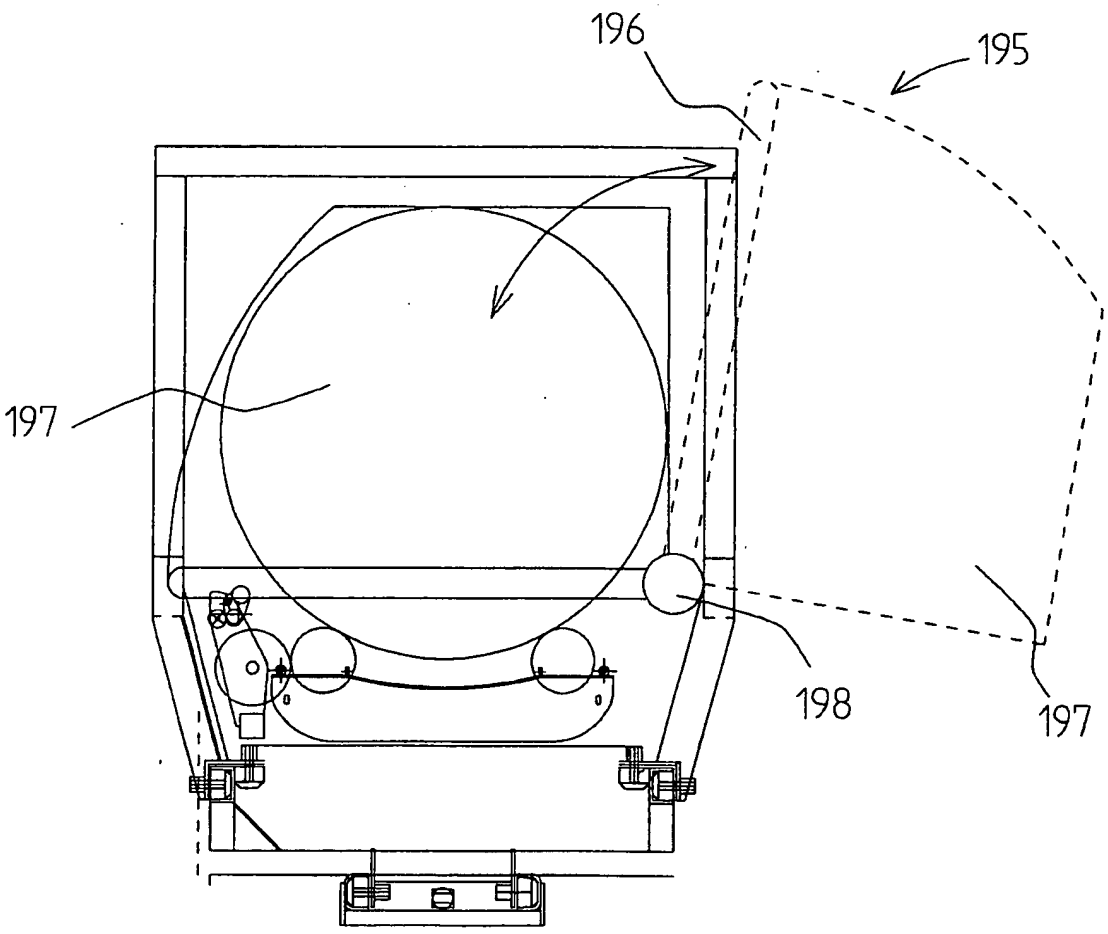

Fig. 17

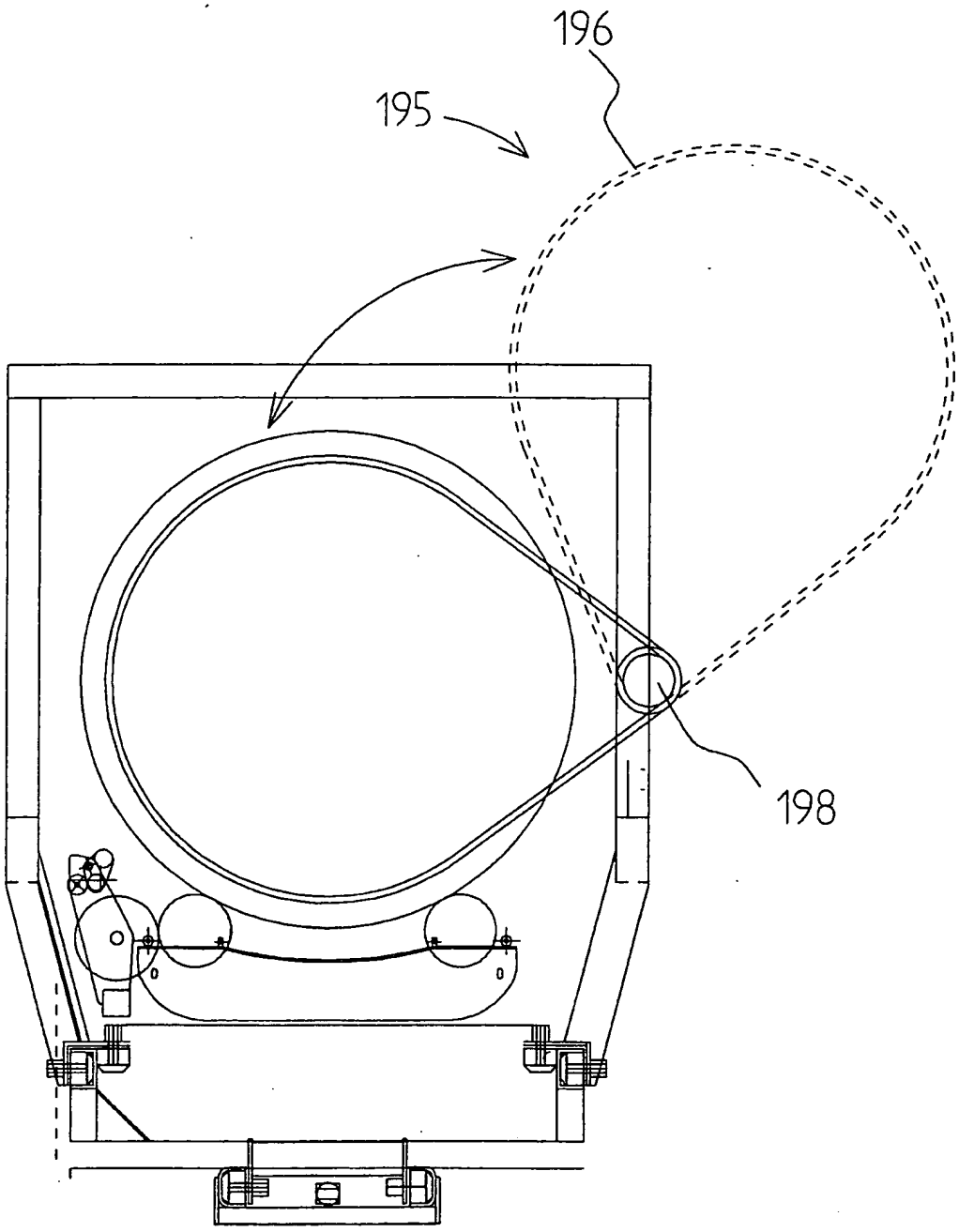

Fig. 18

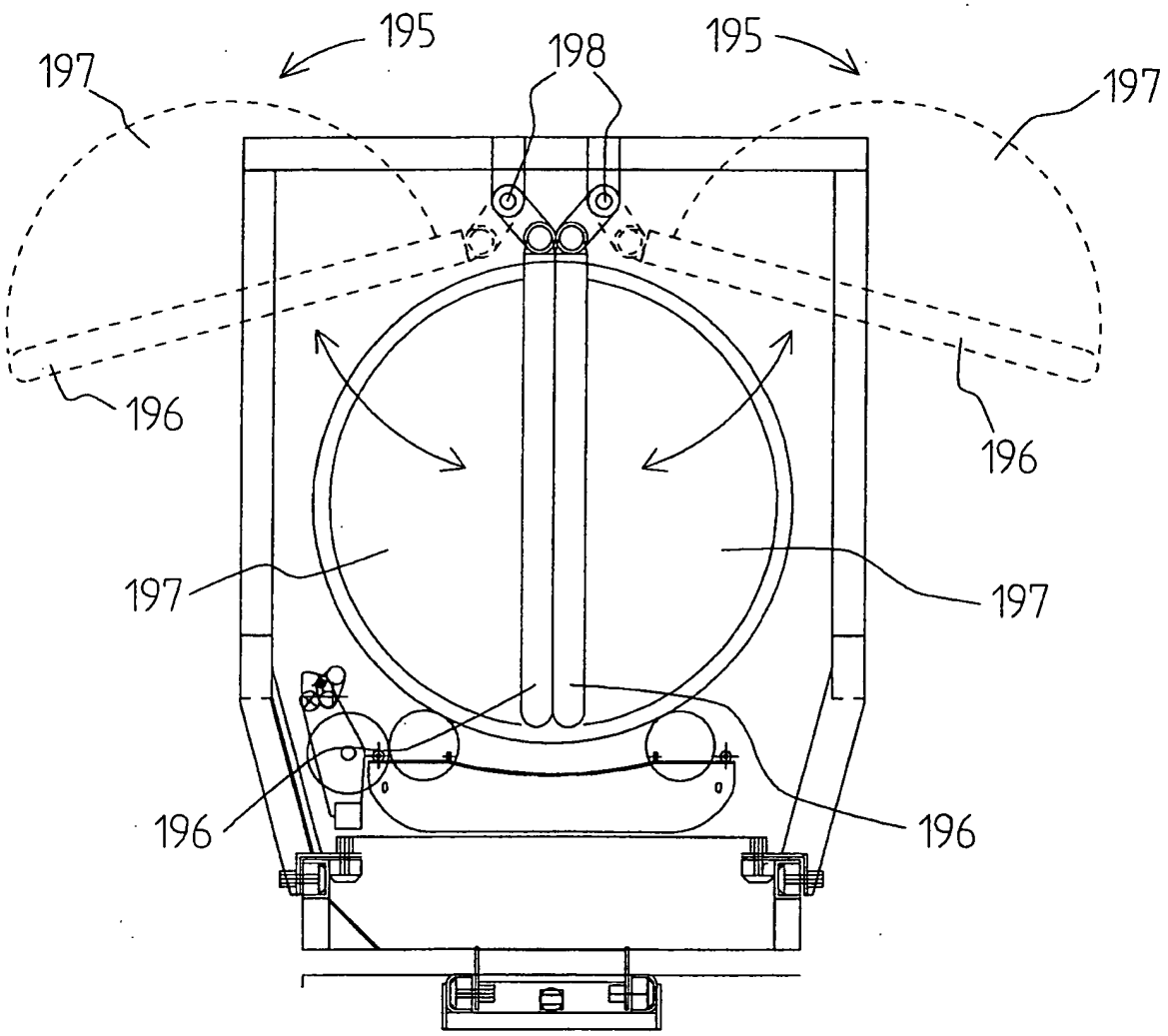

Fig. 19

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/IE 00/00111

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A01F15/07 B65B11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A01F B65B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 553 446 A (SIBLEY DUANE L ET AL) 10 September 1996 (1996-09-10) column 4, line 65 -column 13, line 35; figures 1-15	2,7,9,11
Y		14
A		1,15
Y	WO 99 04613 A (COMTOR LIMITED ;LACEY LIAM J (IE)) 4 February 1999 (1999-02-04) cited in the application page 11, line 21 - line 25	14
A	page 9, line 4 -page 16, line 36; figures 2-20	1,2,15
A	US 5 531 061 A (PETERSON ROBERT W) 2 July 1996 (1996-07-02) column 3, line 31 -column 6, line 37; figures 1,2,12,13	1,2,15

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 November 2000	22/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Herijgers, J

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ional Application No
PCT/IE 00/00111

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